AUTOMATION

OCTOBER 1956

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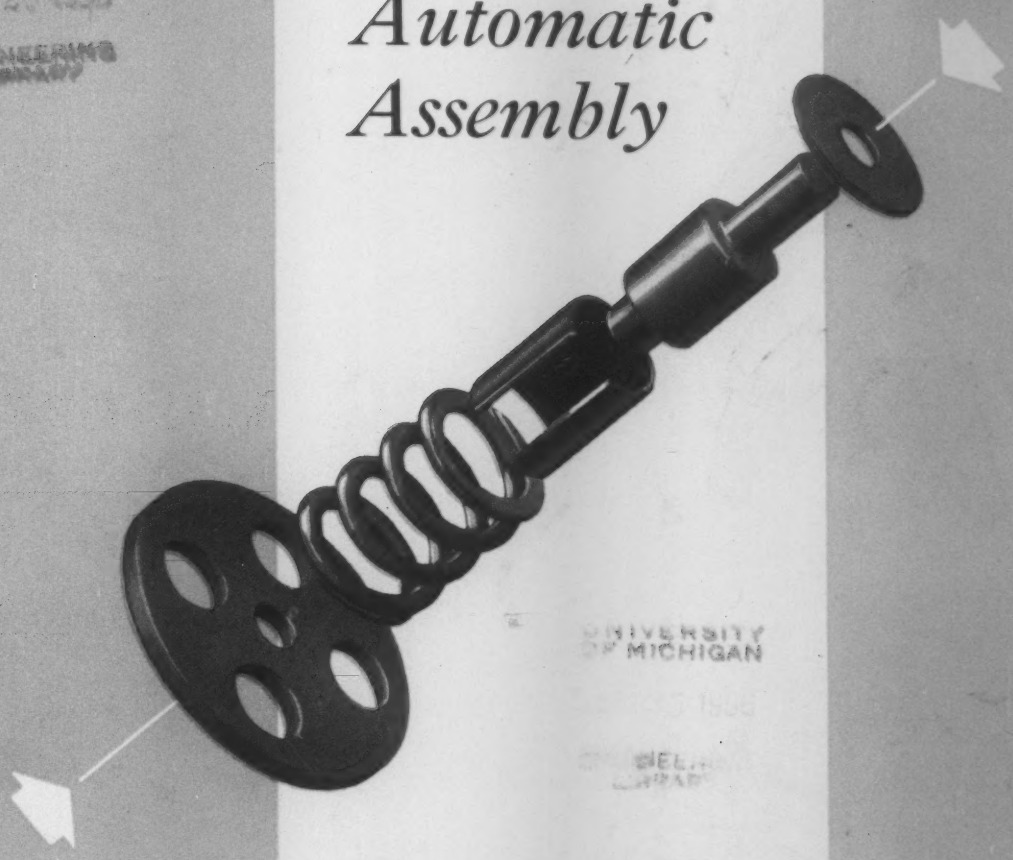

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The Magazine of Automatic Operations

- **Tailoring Automation To Plant Needs**
- **Insertion of Electronic Components**
- **Automatic Temperature Control**
- **Electrohydraulic Devices**

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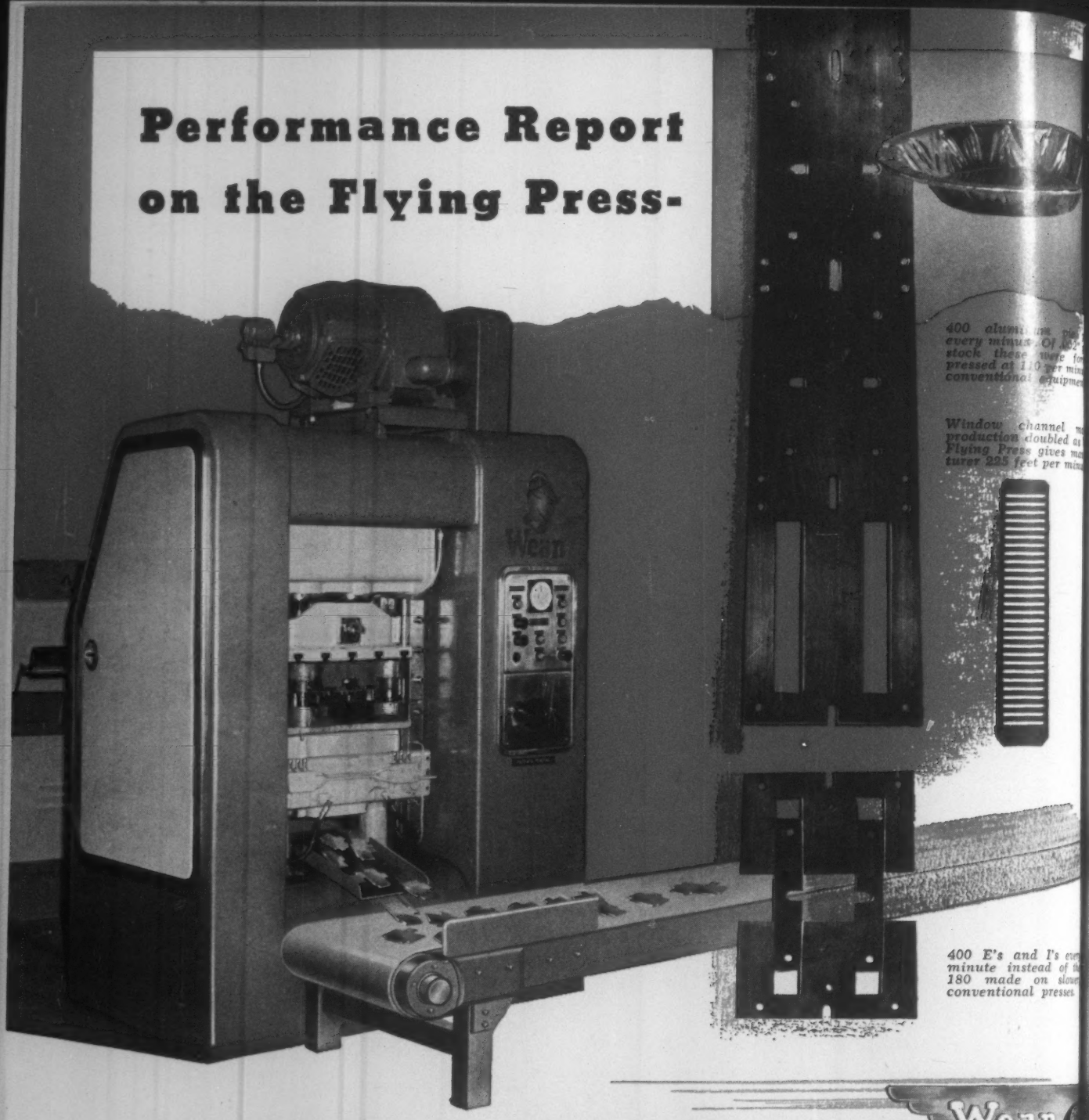
A PENTON PUBLICATION

Performance Report on the Flying Press-



400 aluminum pie... every minute. Of 1/32... stock these were for... pressed at 110 per min... conventional equipme...

Window channel m... production doubled on... Flying Press gives ma... turer 225 feet per min...

400 E's and I's ev... minute instead of th... 180 made on slower... conventional presses.

Revolutionary Wean Press continues to amaze the industry

Since it was first introduced to industry, the Wean Flying Press has commanded the interest of imaginative production people.

On paper, it looked good. Tests on the hand made prototype were even more convincing. But, could a production model achieve such levels under actual operating conditions?

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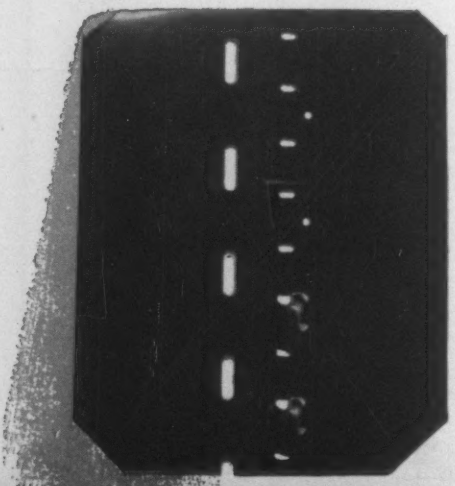
Why not acquaint yourself with this amazing press now? Contact the Wean Sales-Engineer in your area or write direct.



Shallow draw a... punch work on ... gauge stock boo... to 400 pieces ... minute by We... Flying Press.

Wean

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A PENTON PUBLICATION

OCTOBER 1956
Vol. 3—No. 10

AUTOMATION®

THE MAGAZINE OF AUTOMATIC OPERATIONS

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←Circle 555 on Inquiry Card

automation outlook

MOST PUBLICIZED TREND

". . . when speaking of manufacturing operations today, even the general public thinks of automation. It is probably the most publicized trend in business throughout the country. As some of you may know, I coined the word in the year 1936, although the term did not come into extensive use until about 1947. At that time its meaning was largely limited to the linking of machine tools with automatic materials transfer and handling equipment. Today, however, its meaning goes far beyond the definition it had even those few short years ago. Its meaning has expanded and changed with each new application.

"In a relatively short time we expect to have a number of our machine tools being controlled by magnetic tape. It is a new technology that is being developed at an extremely rapid rate throughout the country. In fact, our Chicago Aircraft Engine Division is actively working in this field at the present time. With this method, the machine tools will be controlled by engineering data that is impressed on tapes from our blueprints. The machines would then follow the engineering instructions exactly . . ."—*Del S. Harder, executive vice president, Ford Motor Co.*

LIMITED BY COMPANY ORGANIZATION

". . . the practicability of automated assembly is frequently more limited by the company organization than by its product. For example, the status of the product design department may easily make the difference between an impractical automation project and a very profitable one. When a firm isolates its product design group from the disturbing influences of the manufacturing and tooling personnel; when the firm freezes its designs as originally conceived and when change requests for ease of manufacturing are considered 'too costly' or a nuisance; it is to be expected that many operations will not be automated at all—and many that are will be accomplished at much unnecessary cost. These are recognized facts which many firms are attempting to correct through training of design engineers in manufacturing practices and through establishment of intermediate engineering groups or product 'grooming' departments . . ." —*Kenneth R. Treer, See Page 50.*

DEFINITION

". . . in a general sense, automation is more of a philosophy than an absolute stage in industrial development . . ."—*Robert B. Siedel, president, Automatic Temperature Control Co. Inc., See Page 63.*

CROSS FERTILIZATION APPARENT

". . . cross fertilization is apparent in industry. Process systems of all kinds—heating, mixing, joining, blending, pressing, material handling, inspecting, sorting, packaging—are being cross-fertilized, integrated, to bring together the major advantages of each and to create automation of the highest and most practical order.

Selas is in the thick of this activity with both its heat and fluid processing equipment. No longer is heating merely the consideration of a type of burner; heating—as Selas sees it and designs and builds it—is a process combining, among other things, loading, unloading, time and temperature controls and a fitting of the entire process into a production line . . ."—*High Gradient, No. 25, Selas Corp. of America.*

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BPA NBP

AUTOMATION news

Today's events and developments in the field of automation

Automatic Warning Device Bolsters Defense Procedures

RADIO RECEIVER which operates unattended, provides visual and audible warnings of air alerts, and automatically seeks and finds a Civil Defense "Conelrad" frequency for radio coverage during an enemy attack has been developed by Radio Corp. of America. The unit is expected to develop wide usage as an alert-warning device in industry, business, institutions, and in the home. It operates on 110v ac power.

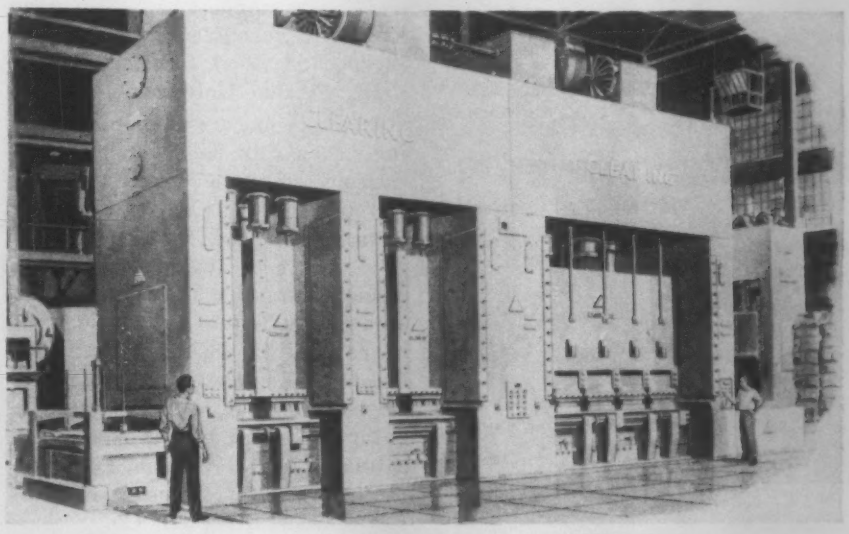
Under Civil Defense procedures, commercial broadcast stations are required to leave the air in the event of enemy air attack to prevent use of their radiated signals as location guideposts. Two Conelrad frequencies (CONtrol of ELectromagnetic RADiation), 640 and 1240 kilocycles, have been established for broadcast of Civil Defense instructions and news during such emergencies.

The RCA Conelrad radio receiver provides a standard radio band, for tuning in any local radio station, and the two Conelrad frequencies. The user can preset, with a simple knob adjustment, the Conelrad frequency assigned to his locality, to provide automatic switchover from standard band operation to the Civil Defense frequency during emergencies.

The receiver can be operated with the speaker *Off* to provide silent sentry duty. If operated *Off*, the speaker automatically is switched *On* with the transmission of a Conelrad alert by the station. A green light glows on the instrument panel to advise that incoming broadcast signals are being received, even with the speaker turned *Off*.

As soon as a broadcast station initiates shut-down procedures, the RCA receiver immediately and automatically shifts to emergency operation. The speaker is automatically switched *On* to receive the complete Conelrad alert from the station. Simultaneously, the receiver begins to shift from the station to the preset Conelrad frequency. Should it reach that frequency before the Conelrad station is on air, the receiver reverts to the broadcast station and continues to shift between the two until it picks up a signal. At the conclusion of the emergency, the receiver automatically shifts from the Conelrad frequency to the broadcast station to which it was tuned.

The instrument also provides visual warnings. When standard broadcast signals are being received, the panel's green light stays on. A red light joins the green one to advise visually whenever the station initiates shut-down procedures by cutting its carrier wave.



ANTICIPATING the need for flexible equipment to provide for future changes in manufacturing requirements, Clearing Machine Corp., Div. of U.S. Industries Inc., has introduced a new modular press design. Drawing shows installation which is capable of producing 700 stampings per hour in a General Electric line making washer and dryer tops. As manufacturing requirements change, above unit might be separated into two presses or additional modular units integrated into the line to increase number of available stations or alter sequence of tonnage capacities.

Programmed Machines Exhibited

NEW TAPE CONTROLLED drill press has been developed by Jones & Lamson Machine Co., and is being demonstrated at their Springfield, Vt. plant. The company is also showing a new and improved version of the tape controlled turret lathe which was first exhibited at the 1955 NMTBA Tool Show in Chicago. Purpose of the demonstration is to show the integration possibilities in a shop equipped with more than one kind of programmed machine.

Outstanding Group Scheduled for Purdue Conference

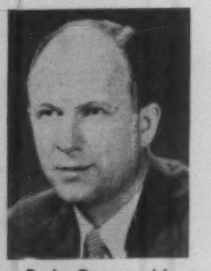
Practicality Will Keynote Three-day Meeting

AS WAS REPORTED last month in AUTOMATION, Purdue University is to be the scene of the First Conference on Manufacturing Automation. The program is cosponsored by Purdue University's School of Mechanical Engineering, and School of Industrial Engineering and AUTOMATION Magazine. The diversified, practical experience of the speakers, who have been drawn from various industries, will provide both the depth and breadth of view so necessary to an intelligent understanding and evaluation of present-day manufacturing automation and its economical advantages. The conference is scheduled to meet Oct. 22, 23, and 24 at Memorial Union Bldg., Purdue University campus.

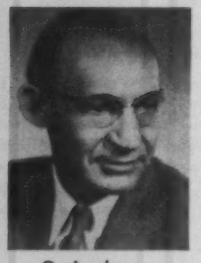
F. F. White

P. H. Alspach

H. M. Gage


R. L. Grunewald

M. D. Braid


O. Jendresen

C. E. Evanson

D. M. Swartz

G. W. Jernstedt

J. C. Keebler

Sessions of Tuesday morning, Oct. 23, will be devoted to a more thorough analysis of some of the fundamental aspects of automation. Evaluation of production economics will be discussed by **C. E. Evanson,** President, T.A.B. Engineers Inc.; plant management and organization points of view will be presented by **D. M. Swartz,** Secretary, Automation Industries

The morning sessions, Monday, Oct. 22, are to be devoted to discussions of both small (simple) and large scale (full-plant) automation, and the various factors affecting these two general areas of manufacturing automation. The area of small-scale automation will be covered by **F. F. White,** Vice President-Engineering, Automation Development Corp. Large-scale automation will be the subject of a talk by **P. H. Alspach,** Manager, Equipment Development Laboratories, General Electric Co.

Afternoon sessions, Monday, Oct. 22, will feature four widely diverse specific cases of applied automation presented in pictorial commentary form in order to highlight the key factors which must be taken into consideration in establishing automation in a plant. Speakers will be: **H. M. Gage,** Assistant to General Manager Marketing, Plumbing and Heating Div., Rheem Mfg. Co.; **R. L. Grunewald,** Manager, EOD Components & Overhaul, General Electric Co.; **M. D. Braid,** Factory Engineer, Valve Div., Thompson Products Inc.; and **O. Jendresen,** Senior Engineer, Parker Pen Co.

W. M. Schweder

D. A. Cargill

R. E. Cross

C. F. Carlzen

F. Johnson

W. M. Willitts

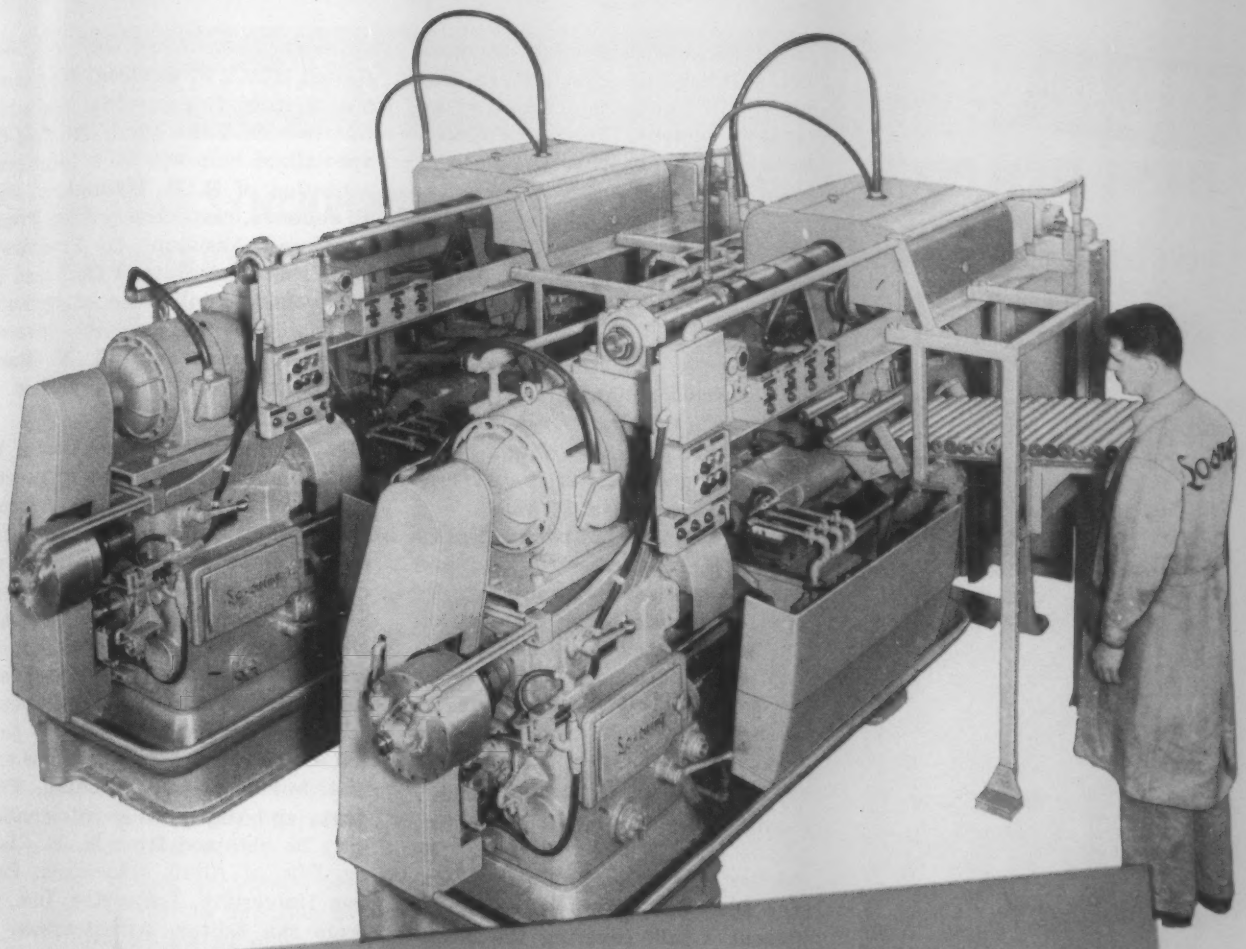
H. Bentley

P. H. Richardson

R. Sattler

R. B. Billingham

I. Ingraham



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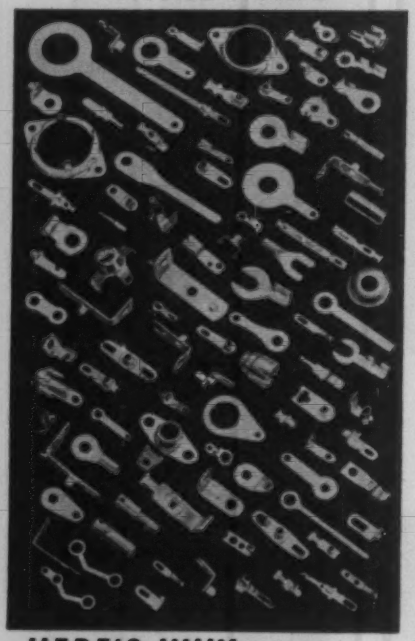

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Inc.; the general problem of making automation effective in the plant will be the topic covered by **G. W. Jernstedt,** Director of Manufacturing Engineering Laboratory, Westinghouse Electric Corp.

In the afternoon, Tuesday, Oct. 23, some of the more pertinent technical aspects will be covered in three sessions. Evaluation and development of a suitable manufacturing cycle will be analyzed by **J. C. Keebler,** Associate Editor, AUTOMATION Magazine; developing production control to obtain flexibility of operations is the general topic to be discussed by **W. M. Willitts,** Engineer, Merrimac Valley Works, Western Electric Co.; and finally, a discussion on product design for manufacturing automation will be presented by **W. M. Schweder,** Manager, Low Integral Horsepower Motor Production, Engineering Sub-Section, Medium Induction Motor Dept., General Electric Co.

At a banquet on Tuesday night, toastmaster **R. W. Bolz,** Editor, AUTOMATION, will introduce **H. Bentley,** Manager, Production, Engine Div., Chrysler Corp., who will present a talk covering the development of a new automated plant based upon his personal experience at Chrysler.

Wednesday morning, Oct. 24, will be devoted to four sessions on the general theme of overall program implementation in relation to some of the primary approaches to manufacturing automation. Possibility of using standard equipment will be discussed by **D. A. Cargill,** President, Cargill Detroit Corp.; build-up of semispecial machines through building block equipment will be the topic of the talk by **P. H. Richardson,** Engineering Vice President, The Hartford Special Machinery Co.; and an analysis of automation and transfer machines will be made by **R. E. Cross,** Executive Vice President, The Cross Co. The morning session will conclude with a presentation on special-purpose production lines by **R. Sattler,** Vice President, LaSalle Tool Co.

Proceeding from the comprehensive background data which characterizes all previous sessions, the final talks in the afternoon, Oct. 24, will consider possible methods to use in automating a desired operation. Advantages of the "do-it-yourself" approach will be discussed by **C. F. Carlzen,** Manager, Automation Engineering, Sylvania Electric Products Inc.; the role of specialized help will be a joint presentation of **R. B. Billingham** and **F. Johnson,** respectively Vice President and Assistant to President, W. F. & John Barnes Co.; and in a concluding talk, use of consultants will be the subject covered by **I. Ingraham** and **J. Y. Rust,** Professional Engineers, Giffels & Vallet Inc.

In keeping with the desire to make the conference one of practical benefit to those in attendance, time for questions and audience discussion will be included in all sessions; and between the scheduled lectures, conference members will be afforded an opportunity to inspect a number of automation exhibits prepared by leading industrial firms. Papers will be published following the conference and distributed to all attending. Program and registration information may be obtained from **K. E. Glancy,** Div. of Adult Education, Purdue University, Lafayette, Ind., or from the Editor, AUTOMATION.

Improved Quotation System Speeds Stock Trading

ELECTRONICALLY operated magnetic drum memory has been added to the automatic stock quotation system serving the Toronto Stock Exchange. The system was designed and built by the Teleregister Corp. The newly expanded system provides brokerage offices with a panel which instantaneously and automatically displays latest bid and asked prices on any 50 stocks of primary interest to a given broker. As each quotation is recorded from the Exchange floor, an operator punches it up on a keyboard which transfers the price to the magnetic memory device located in the Exchange building. This device automatically sends the prices out by direct wires to all subscribers' offices, and at the same time causes them to appear on the display panels.

The system will supplement a dial service which presently provides the brokers with bid-asked

another example of precision synchronization . . . by VICKERS

PRECISE SYNCHRONIZATION OF AUXILIARY ALTERNATOR WITH POWER-DISTRIBUTION LINE

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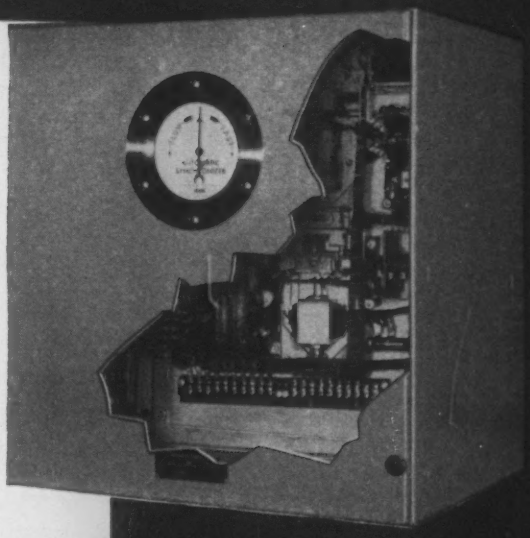


A leading manufacturer of diesel-driven auxiliary power generating equipment achieves precise synchronization of the alternator with the main power line when paralleling with the use of Vickers Automatic Alternator Synchronizers.

The Vickers synchronizer automatically

- Matches the frequency of the alternator to that of the main power line to within 1/5 cycle per second by controlling the diesel governor.
- Closes the circuit breaker which parallels the alternator with the line at the instant of phase synchronization by means of a phase detector and anticipation circuit.

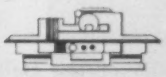
Free of vacuum tubes, and with a minimum of moving parts, Vickers automatic synchronizers utilize static magnetic amplifiers for trouble-free performance under adverse conditions with little or no maintenance.

■ ■ ■

Some of the Many Other Applications for Vickers Automatic Synchronizers

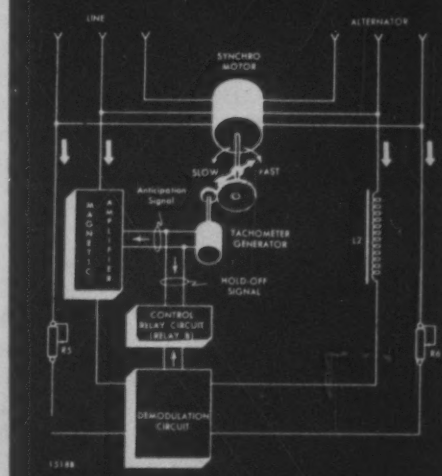
AIRCRAFT PROPELLERS

CONVEYORS



TRANSFER MACHINES

Vickers control engineers will work with you in solving *your* synchronization problems.



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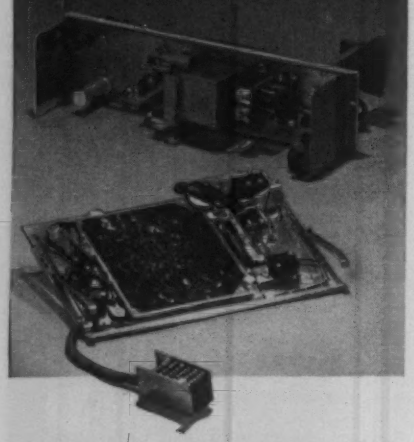

designed for industrial applications and made by STROMBERG-CARLSON

When you learn what telephone companies do with these products, a dozen applications to *your* problem will come to mind.

The XY Tape Recorder is used in connection with long-distance telephone calls for recording data on a sequential basis, and later reading out the information at very high speed. Mighty useful in data processing.

The Tape Announcer is used to substitute a pre-recorded message for interception by a telephone operator—in cases like wrong numbers dialed, discontinued numbers and the like. It can be used in conjunction with any communication system.

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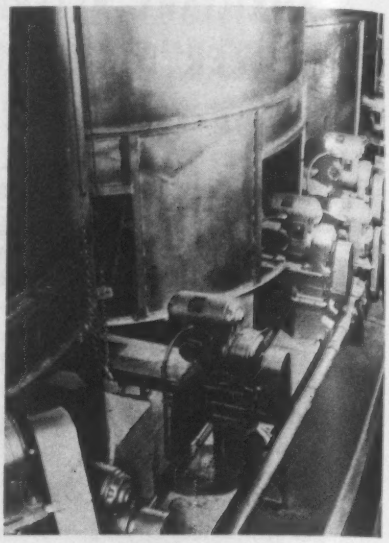
prices on all listed stocks on the Exchange. With selected stocks automatically displayed, it is expected that the demand on the automatic dial system will be greatly reduced—and consequently will speed up the response of the entire system during heavy trading. The techniques used by Teleregister in developing the system are similar to those used by airline and railroad companies in handling passenger reservations.

To Furnish Controls For Earth-Satellite Rocket

AUTOMATIC pilot for controlling flight of the earth-satellite rocket will be built by Vickers Electric Div. of Vickers Inc. The company will design and manufacture the flight control device under a Navy contract let through the Glenn L. Martin Co., prime contractor for the earth-satellite launching vehicle.

Vickers' control apparatus, built around a magnetic amplifier, will be used to accomplish the necessary changes in course of the rocket by altering position of rocket engines at the base of the first and second rockets of the proposed three-stage rocket vehicle. The engines, mounted on a sort of universal joint called a gimbal, will be installed in such a way that they can readily be shifted about. As the bottom and middle rockets use up their fuel and burn out, they are to drop off. The Vickers' device will not be built into the topmost and final stage, but will give it a final positional fillip as the second stage is jettisoned.

FORMATION of the Bell Automation Corp. has been announced by the Bell Aircraft Corp. Company will be a new wholly owned subsidiary to specialize in the fields of automatic controls and systems. First product to be introduced by the new company is the Electro-Way, an electronically controlled, continuous weighing system for conveyor belt handling of bulk materials. President of the new corporation is **Leston Fanneuf,** vice president and general manager of Bell Aircraft Corp. Key technical personnel were drawn from Bell Aircraft's electronics engineering department and will be under the active direction of **Frank S. McCullough,** newly named general manager.



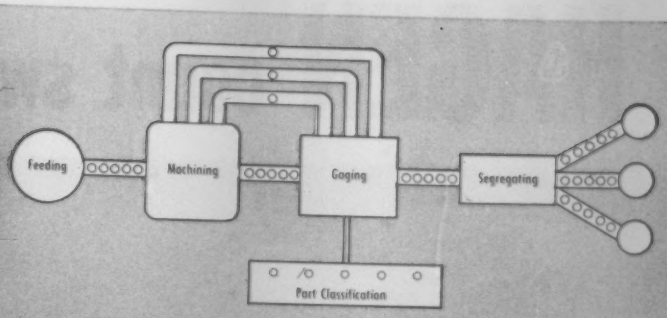
CONTINUOUS mixing of various quantities of dry solids is problem in animal feed proportioning. Mixtures must be varied constantly to adjust for weather, quality of feed, etc. System designed by Thompson & Gill utilizes Speed-Trol manufactured by Sterling Electric Motors Inc. Each feed bin has screw conveyor at bottom which is driven by variable speed drive and which feeds into large main screw conveyor leading to sacking machine or storage bin. Calibration of system provides data for speed drive settings to obtain any combination of ingredients to be mixed automatically.

Selective Calling System Simplifies Remote Control

SELECTIVE signaling device which relieves pilots of the task of continuously monitoring a radio channel has been announced by the Dualex Div., Bell & Gossett Co., Morton Grove, Ill. Unit consists of a selective calling receiver which performs the same function as a telephone bell and a selective calling transmitter which functions as the dial in the telephone system.

Simply by setting the call number of a particular aircraft on the five-dial transmitter, the sender can alert only the one receiving aircraft by a flashing light in the cockpit. The pilot then turns on his radio receiver to hear the message. With the five-dial transmit-

AUTOMATION DEMANDS RELIABLE CONTROLS



Dimensional control is the very heart of automation for the metalworking industry. Consequently, care in the selection of In-Process and Post-Process control devices is very important.

As a long recognized leader in air, electric and electronic gaging, Sheffield is prepared to furnish either:

- **Packaged controls and tooling ready to install**
- **Complete automation gaging and transfer systems ready to operate**

FUNCTIONS and ADVANTAGES

- Determine minute dimensional variations, rapidly and with repetitive precision
- Initiate warning signals
- Actuate control mechanisms
- Segregate acceptable, oversize and undersize parts
- Accurately classify parts by sizes
- Accommodate almost limitless range of tolerances
- Operate with interchangeable tooling
- Are small, compact and easily mounted
- Have unusually long, trouble-free service life
- Are easily interchanged

7125

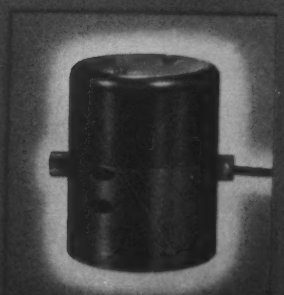
Shown here are a few of those Sheffield control units so widely used in automated systems.

AIRLECTRIC

A limit type pneumatic control to actuate signals and relays.

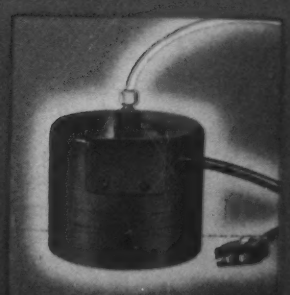
LECTROLAIR

A sealed-in control to actuate signals and relays and also to give visual size indication.



DIFFERENTIAL

A gage head for checking taper, hole parallelism or hole center distance and converting the result into an actuating electrical impulse.



VARIATION

A pneumatic gage head for external or internal dimensions and face to axis runout—converts the result into an actuating electrical impulse.

For more detailed information, write for Bulletin AU-1154

The Sheffield Corporation
Division 3
Dayton 1, Ohio, U.S.A.

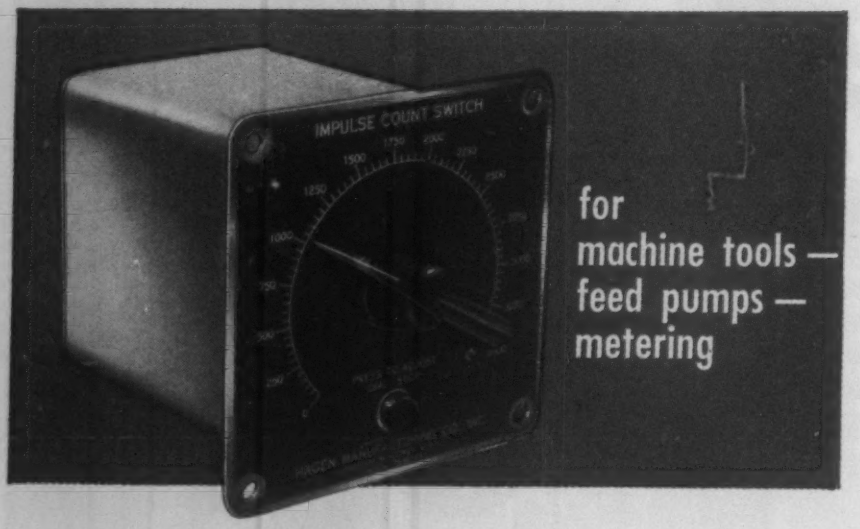
MASTER CRAFTSMAN SHEFFIELD HEADQUARTERS

SHEFFIELD

MANUFACTURE AND MEASUREMENT FOR MANKIND

Circle 563 on Inquiry Card

HAGEN count switch



for machine tools — feed pumps — metering

PAID FOR BY SAVINGS MADE ON JUST 1 TOOL

Simply set this Hagen Count Switch to the number of operations at which a tool should be changed. The count switch trips a switch after a preset number of electrical impulses . . . and thereby shuts down the machine automatically. Tool wear never reaches the point where tools must be ground down excessively to resharpen. That means increased tool life, reduced tooling costs and fewer rejects. Compare the savings on just *one* tool with the cost of this reasonably priced Hagen Count Switch. Chances are, the savings will be much greater.

This Hagen Model 70 Count Switch has 72 dial divisions . . . 72 possible settings. Dials are available with up to 54,000 counts. Accuracy: 1% of full scale range. Ideal for feed pumps and metering operations. Send coupon for Bulletin 780 — or data on the complete line of reset and repeating cycle timers and counters, interrupters and control assemblies.

MAIL COUPON TODAY!

HAGEN MANUFACTURING COMPANY, INC.
Dept. A-1056, Moline, Illinois

☐ Please send free Bulletin 780 on Hagen Count Switch.

☐ Send free data on counters, timers, interrupters and control assemblies.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

Circle 564 on Inquiry Card

ter, any one of 100,000 different planes can be called.

An auxiliary plug-in function control unit is available for use with the receiver unit in the airplane. It enables the ground operator to control up to nine individual electrical functions in the aircraft in addition to the normal alerting function. Each of these functions or circuits may be individually turned *On* or *Off* from the ground without attention from the pilot. Examples would be reading data off the weather warning radar system, or receiving visual information from a television camera in the nose of the plane, now projected as a new means of controlling traffic.

The Dualex selective calling system is not confined in application to aircraft. It offers a remote call and control service to taxicab companies, truck fleets, ships, railroads or to trigger remote operations along an area route.

Another application potential lies in the new field of manufacturing automation. The digital selective calling system is a fundamental means of establishing controls which have virtually no limitation. It is elemental and practical in its methods and lends itself to the thinking of engineers who are trained to think in terms of logic and mathematical sequence.

ACQUISITION of the Metal Processing Machine Co. by McKay Machine Co. has been announced by **A. J. Wardle Jr.**, president of McKay. Metal Processing specializes in shear welders for joining steel and nonferrous strip, continuous tube mill feeders and loopers, payoff reels, tension reels, sheet pilers, pinch roll units, coil lifts and transfers and automated tube and pipe handling equipment. It will operate as a separate company but will tie-in with McKay on sales, sales service and engineering. **R. T. Klempay**, formerly president of Metal Processing has been appointed vice president and general manager.

The McKay Machine Co. designs and builds tube and pipe mills, automated lines for cold drawing and processing of hot rolled bars, roller levelers and related equip-

AUTOMATION
READER SERVICE

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417	447	477	507	537	567	597	627	657
418	448	478	508	538	568	598	628	658
419	449	479	509	539	569	599	629	659
420	450	480	510	540	570	600	630	660
421	451	481	511	541	571	601	631	661
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424	454	484	514	544	574	604	634	664
425	455	485	515	545	575	605	635	665
426	456	486	516	546	576	606	636	666
427	457	487	517	547	577	607	637	667
428	458	488	518	548	578	608	638	668
429	459	489	519	549	579	609	639	669
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AUTOMATION

Information Service

For your convenience, advertisements and items of information on new equipment, components and manufacturers literature now can be quickly identified by an *Item Number* printed just below each unit.

For additional free information circle item number on an inquiry card. Fill in your name, title, address, etc.—Drop it in the mail—No Postage Required—Your request will receive prompt attention and will be filled directly by the manufacturer.

So that you won't have to clip this issue, we will gladly send you a personal copy of any article. Just fill in the page number and title of the article you desire.

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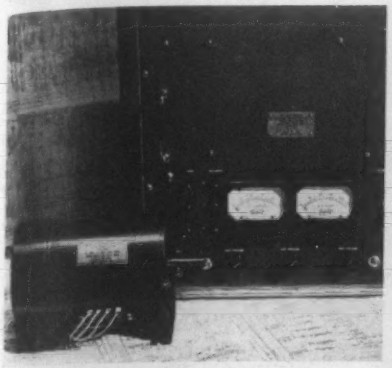
Keep Up-to-Date!

ment for the steel, nonferrous metal, automotive and other industries.

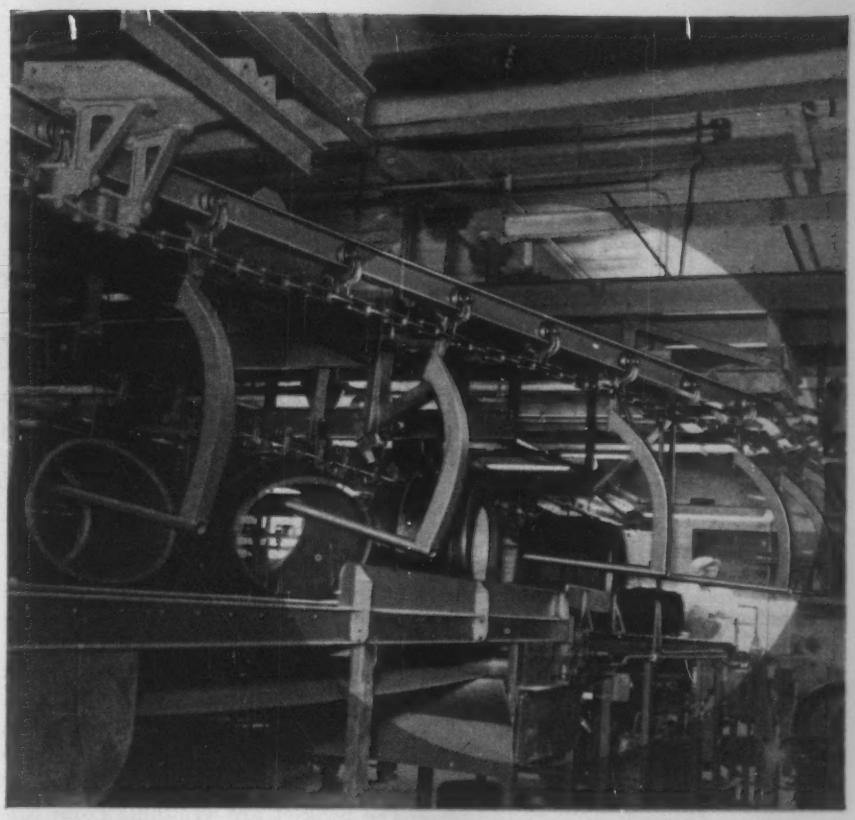


AUTOMATIC control system manufactured by Teller Co., Butler, Pa., is built around tape or punched card controlled step motors. Simplified amplifier permits a multiple series of operations to be programmed for control of several motors in a co-ordinated system such as is found in automated machine tool operations (see Automation Mar. 55, Pg. 62). Acceleration and deceleration characteristics of the motor plus sensitive step control through tape medium provide an electrical gear system of sufficient reliability to eliminate, in general, the necessity of incorporating feedback provisions in the control system.

Automatic Assembly System For Communication Equipment

CONTRACT for the pilot automatic production of Army Signal Corps communications equipment has been awarded the Light Military Electronic Equipment Dept. of the General Electric Co. Contract covers installation, proof testing, pilot production runs, and evaluation of the Signal Corps automatic component assembly system.

System consists of a group of six integrated machines designed for the specific production requirements of military electronic equipment. Special flexibility is required for military electronics production since comparatively small quantities with a high degree of variety are run. The system's six production machines are programmed, or set up and operated in correct sequence by coded punched cards run through an electrical reader which relays the information to the machines. To change the system over for the production of a different type of equipment, the operators need only insert a group of punch cards for the operation,



Transfer Point...

... where tire carcasses get off to stand inspection

Tires ride practically all the way from first operation to shipping dock. Now and then they get off and walk—or roll.

Here carcasses from the tire-making machines arrive by MHS Monoveyor and are automatically transferred by synchronized belt conveyor to a length of gravity conveyor. On this they roll to an inspection station, shown in right background.

There's no lifting of heavy carcasses, no concentration of labor, no pile-up of materials. The MHS materials handling system sets an easy pace, does the heavy work, saves human energy for tasks which add value to the product.

Your production, too, can benefit from skillfully planned automatic materials handling. Call in the MHS engineer for expert assistance.

MHS

Mechanical Handling Systems Inc.
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FACTORIES: Detroit, Mich. • Fairfield, Iowa • Albany, N. Y. • Windsor, Ontario

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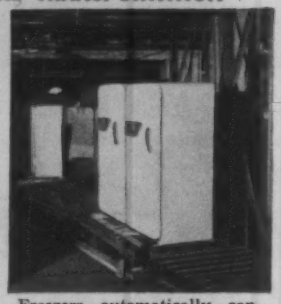
SPEED UP
"Between-Floors"
CONVEYOR LINES

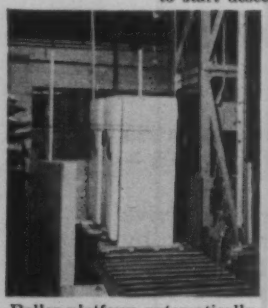
Weld-Bilt
Automatic
"VERTICAL
TRANSPORTATION"

Weld-Bilt Floor-to-Floor Elevators are designed to improve your conveyorizing between two or three floor levels. Highly versatile in application, they provide completely automatic loading, unloading, lifting or lowering — with limit controls, brakes, inclinable or mechanical platforms, selector push buttons in any combination to suit your product and conveyor systems.

TYPICAL WELD-BILT
"VERTICAL TRANSPORTATION"



Freezers automatically conveyed to elevator on top floor. Freezer weight trips controls to start descent.



Roller platform automatically tilts at lower level to discharge freezers to conveyor. Load release starts elevator ascent to top floor.

If your production flow can benefit by floor-to-floor conveyorizing, write for suggestions on Weld-Bilt "Vertical Transportation."

Weld-Bilt Automatic Conveyor-Lifts Elevators, Portable Elevators, Drum Elevators, Lift Trucks, Pallet Trucks, Hydraulic Lift Tables, Skid Platforms, Special Equipment.

WEST BEND EQUIPMENT CORP.
MATERIALS HANDLING ENGINEERS
347 WEST WATER STREET • WEST BEND, WIS.

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and feed in the necessary components.

In operation, the system automatically prepares and tests components and conveys them in magazines to a placement head, transports printed wiring boards under the placement head, inserts the components in the boards, dip solders the completed units, and tests them. The system is expected to place 1600 components per hour, to dip solder approximately 120 wiring boards per hour, and to complete five electrical tests per second.

List of Films Available

NATIONAL Machine Tool Builders' Association has published a new booklet which lists films available for loan to interested companies. The films, concerned with machine tools and machining operations, were prepared for sales or training purposes by member companies of NMTBA. Copies of the booklet are available from National Machine Tool Builders' Association, 2071 E. 102nd St., Cleveland 6, O.

ENLARGEMENT of its air conditioner production facilities with the addition of a new $1½ million machine line has been announced by the Airtemp Div., Chrysler Corp. Line has been introduced for the manufacturing of three new air conditioner compressors: One for the company's car air conditioner and two hermetically sealed compressors for home air conditioning units. The 100-foot long line will provide for 80 automated machining operations on the compressor crankcase castings. As part of the overall expansion program, the company is also installing a pair of new automatic coil making machines which will turn out car air conditioning cooling coils.

Instrument Measures Flow By Heat Transfer Rate

NEW FLOWMETER manufactured by Industrial Development Laboratories Inc. is based upon rate of heat transfer in the boundary layer of a flowing fluid. Heat is produced electrically in a heater coil wound around the outside of a flow tube and a differential temperature between two thermometer coils, located on either side of the heater coil, determines an output voltage which is a function of both the fluid and mass flow rate and power dissipated in the heater coil.

In operation a constant temperature differential (about 1C) is maintained at all flow rates by means of a self-balancing bridge incorporating both resistance thermometers. The wattage is automatically varied by an electronic control system in response to the varying flow rates. The direction of change of power input to the heater is such as to restore the bridge balance, thus providing a closed servoloop system. The flow rate is indicated by a properly calibrated wattmeter and the total

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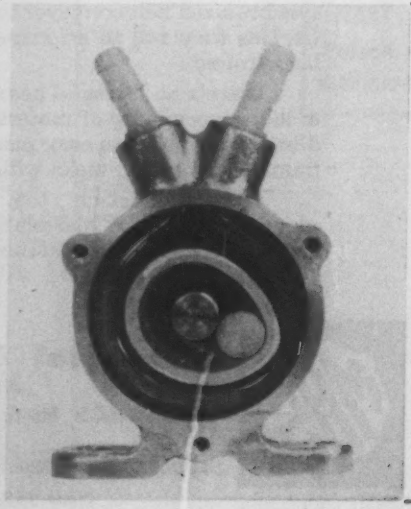
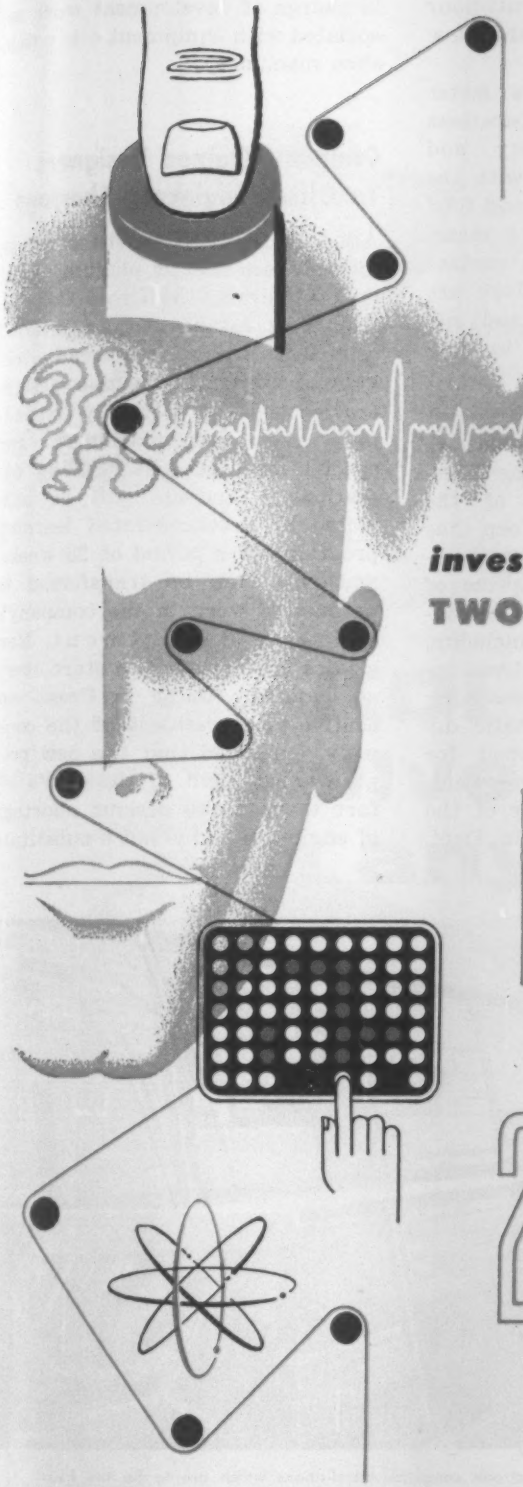


SMALL CAPACITY pumping applications are enhanced with new pump based on old principle. Around a central drive shaft revolves a direct drive nylon rotor in a planetary motion. The nylon roller exerts pressure against a vinyl roller-tube guard which in turn gently, progressively kneads the vinyl pumping tube carrying the fluid. This imparts a positive directional flow to the fluid or gas being pumped. As can be seen, the liquid or gas being pumped is always contained within the chemically resistant tube and thus stuffing box and mechanical seal leakage is eliminated. The unit lends itself to a simplified construction which permits ease of maintenance and complete accessibility to all parts.



need creative automation assistance?

investigate W. F. & JOHN BARNES TWO-FOLD AUTOMATION SERVICE

1 ENGINEERING COMPLETE PRODUCTION-LINE SYSTEMS

Complete service includes planning step-by-step sequence of operations and the individual engineering of processes, methods and equipment to meet your production needs. Barnes' creative engineering, developed over a period of 80 years in designing and building high production machine tools, can be depended upon to provide you with the latest in cost-cutting methods. Our highly versatile engineering staff will work with you as a team to solve problems quickly and efficiently.

2 DESIGNING AND BUILDING SPECIAL UNITS

To meet specific work-handling or processing needs, Barnes' engineers have designed and built special conveyors, turn-over mechanisms, inspection, and assembling equipment to suit either automatic or semi-automatic requirements. Hundreds of units are today profitably serving a wide range of industries. Because electrical, hydraulic, mechanical, tool and fixture engineering is closely coordinated at Barnes under one roof, you save time and eliminate divided responsibility.

Write for Free Literature

Ask for Production Analysis

Find out today why more and more production executives are turning to Barnes for help with their automation problems. Barnes' creative engineering staff will be pleased to analyze your requirements, offer recommendations, and provide you with a cost estimate in a formal proposal, if you desire.

Builders of Better Machines and Equipment since 1872

W. F. & JOHN BARNES

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414 S. WATER ST. • ROCKFORD, ILLINOIS

SPECIAL MULTIPLE SPINDLE MACHINE TOOLS • SPECIAL PROCESS EQUIPMENT • SPECIAL ELECTRICAL CONTROLS

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PRODUCTION ENGINEERS

JOIN THE LEADER IN AERO CONTROLS!

Honeywell needs top-notch Process Engineers at all levels of responsibility for directing the production of such *airborne* control systems as:

INERTIAL GUIDANCE
INLET AREA CONTROL
JET ENGINE CONTROL
FIRE CONTROL AND BOMBING
FLIGHT CONTROL SYSTEMS
FUEL MEASUREMENT AND MANAGEMENT
EXHAUST GAS TEMPERATURE INDICATION

Engineers selected will analyze designs, establish process methods and control, and guide designs toward economical and speedy production.

■ To qualify, you should be familiar with process evaluation, cost estimating, tool ordering, metals fabrication, and manufacturing-assembly operations. Your background should be in the area of *precision* electrical, mechanical, or hydraulic devices such as gyros, accelerometers, operational computers, pressure switches, amplifiers, calibrators, altitude compensators, and thermistor level switches.

■ These are permanent, career-building positions that Honeywell can offer because of its succession of achievements in airborne control systems, broad diversification, and healthy balance between civilian and military contracts.

CONSIDER THESE ADVANTAGES

■ Minneapolis offers you metropolitan living with a suburban way of life . . . A city of beautiful lakes with every recreational facility a few minutes from your home.

■ Outstanding educational opportunities . . . Liberal tuition allowances paid by Honeywell.

■ Plant and technical facilities among the best in the industry.

■ Honeywell pays your family moving expenses.

■ Salaries, insurance-pension programs are all first rate

■ Honeywell, the nation's leading supplier of control systems, manufactures over 10,000 diversified products. A sound growth company, Honeywell offers continuing expansion and permanent opportunities for you to advance.

WRITE TO US

If you are interested in a career at Honeywell, call collect or send your résumé to Bruce Wood, Technical Director, Dept. AU-10-108, Aeronautical Division, 2600 Ridgway Road, Minneapolis 13.

MINNEAPOLIS **Honeywell**
First in Controls

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flow is indicated by a watt-hour meter which integrates the flow rate.

The Electro-Caloric flow meter is particularly useful in operations requiring sanitary, safety and other features associated with the chemical, pharmaceutical, and food processing industries. The measuring elements are not in contact with the fluid and therefore are not exposed to chemical and mechanical attack or subject to clogging.

APPOINTMENT of **Donald E. Houser** as manager of the Electronic Equipment Dept. of the United Shoe Machinery Corp. has been announced. Houser will supervise all commercial aspects of the company's automatic electronic inserting machinery including the Dynasert conveyor systems, individual semiautomatic inserting machines, and new automatic dip soldering machine developed for use with the Dynasert equipment. He was formerly manager of the company's Special Projects Dept. in charge of development work associated with equipment other than shoe machinery.

Company Trained Designers To Offset Engineeer Shortage

AS A SOLUTION to the shortage of engineers that is plaguing most manufacturers, the Cross Co., Detroit, has established an internal company school specifically organized to train machine designers for the firm's rapidly expanding automation machinery and special machine tool building operations. Students will be subjected to a concentrated learning program for a period of 26 weeks, and will then be transferred to productive work in the company's engineering department. New classes are expected to start every six months. **Ralph E. Cross**, executive vice president of the company, explained that the new program is a result of the firm's effort to ease the serious shortage of engineers and is not a substitute

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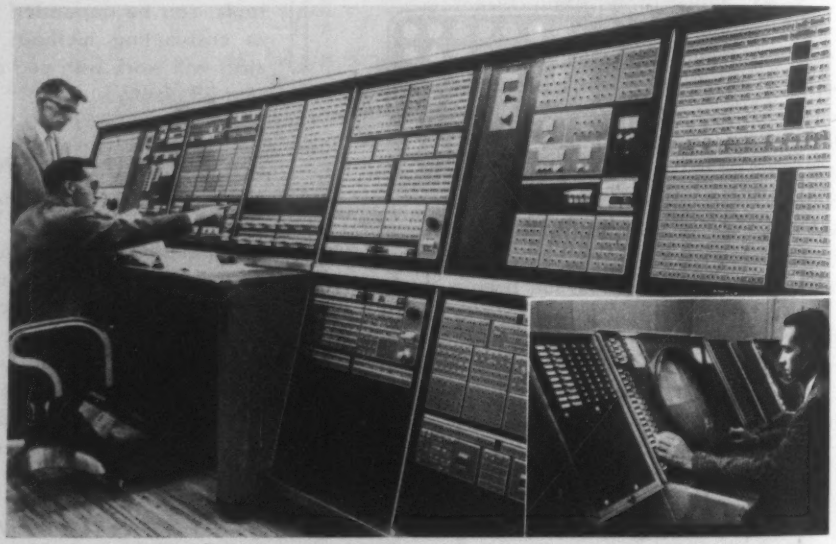
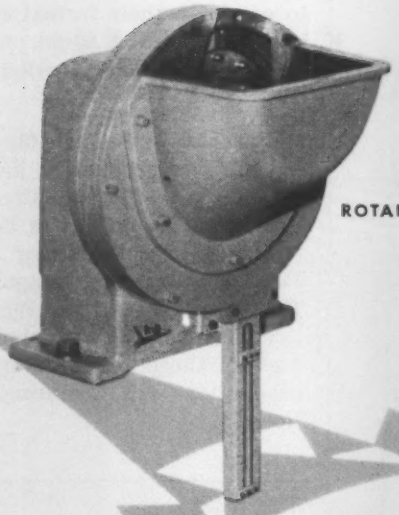


FIRST of the tremendous electronic computer installations which are to be the heart of the nation's new air warning network is in the process of being shipped to McGuire Air Force base by IBM. Tagged the Semi-Automatic Ground Environment (SAGE) system, it utilizes a computer to receive information, to memorize, to calculate, to record answers and with the perspective and display talents of radar, to present an instantaneous graphic picture of the location, speed, and direction of all planes within radar range. The system links together radar installations on land, on Navy picket ships at sea, on offshore Texas towers, and on airborne early warning planes ranging far out over the ocean. Information anywhere within the radar area is relayed continuously and automatically to the computer. The illustrated control console contains all of the controls for operating the computer. It displays the operating status of the equipment to personnel who continually monitor the computer's operation. The illustrated display console presents a picture of the air defense situation to operating personnel and with the aid of buttons and switches located on the side of the console, Air Force personnel can make tactical decisions which in turn will be carried out automatically by the computer in setting up the most effective defense operation.



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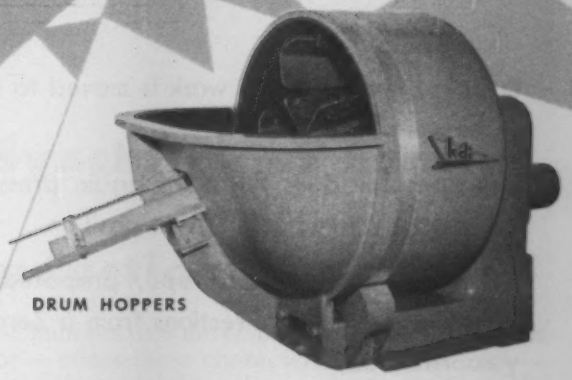
CENTRIFEED HOPPERS

KDI Hoppers deliver your part in any direction

SHAFT HOPPERS



DRUM HOPPERS

KDI CORPORATION

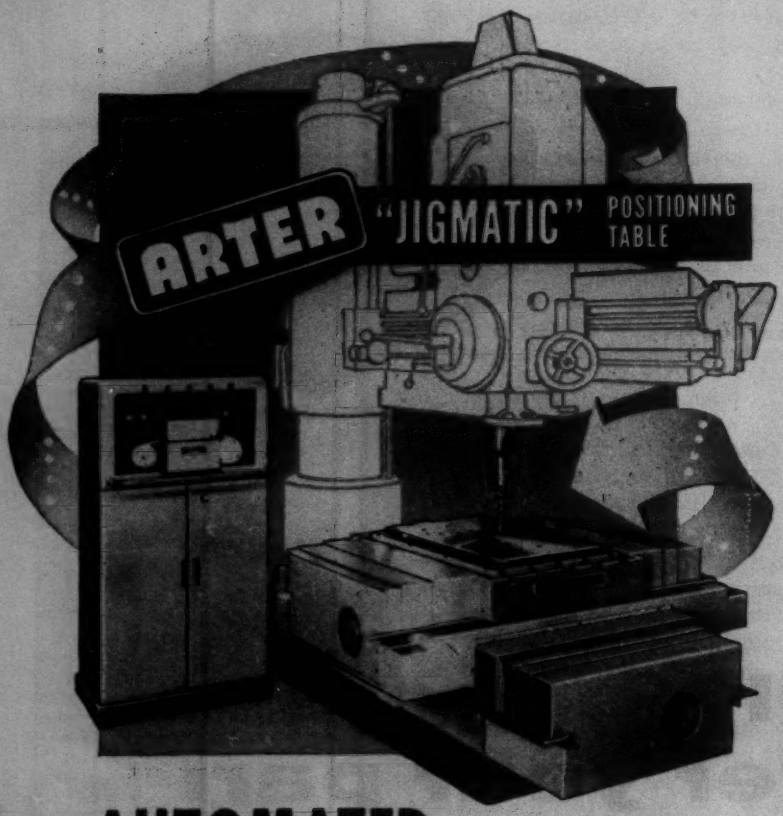
FORMERLY KRAUS DESIGN, INC.

950 EXCHANGE STREET • ROCHESTER 8, N. Y.

SPECIALISTS IN MECHANICAL HOPPERING, AUTOMATIC ASSEMBLY MACHINES, AND INTEGRATED PARTS PRODUCTION LINES

kdi

Send sample parts and production details for engineering recommendations.



for AUTOMATED Tape Controlled SPACING!

Press a button and the work is moved to an exact position under the drill.

The operator drills the hole, again presses a button and the work is moved to the next position.

It's all in the punched tape, prepared from drawings, dimensioned in two directions from a Zero corner. (x and y coordinates.)

The "reader" interprets the punched holes and both tables are moved simultaneously.

Accuracy of positioning is .001", load capacity 1,000 pounds, shipping weight 8,000 pounds.

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Jigmatic Automatic Tape Controlled Positioning Table • Rotary Surface Grinders
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AGENTS IN INDUSTRIAL CENTERS OF UNITED STATES AND CANADA

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for an engineering degree. He said, "The schooling is designed to fill our particular needs in the future, and all trainees will be urged to complete their formal engineering schooling at night, following the first six months period."

NEW color and sound film featuring various production line applications of electrostatic spray painting equipment has been prepared by the Ransburg Electro-Coating Corp., Indianapolis, Ind. The film, entitled "The Big Attraction" is available for plant showings for those interested in factory production line painting operations.

MEETINGS AND EVENTS

Oct. 18-19—
National Conference on Industrial Hydraulics. To be held Hotel Sherman, Chicago. Additional information may be obtained from V. J. Danilov, Illinois Institute of Technology, 35 W. 33rd St., Technology Center, Chicago 16, Ill.

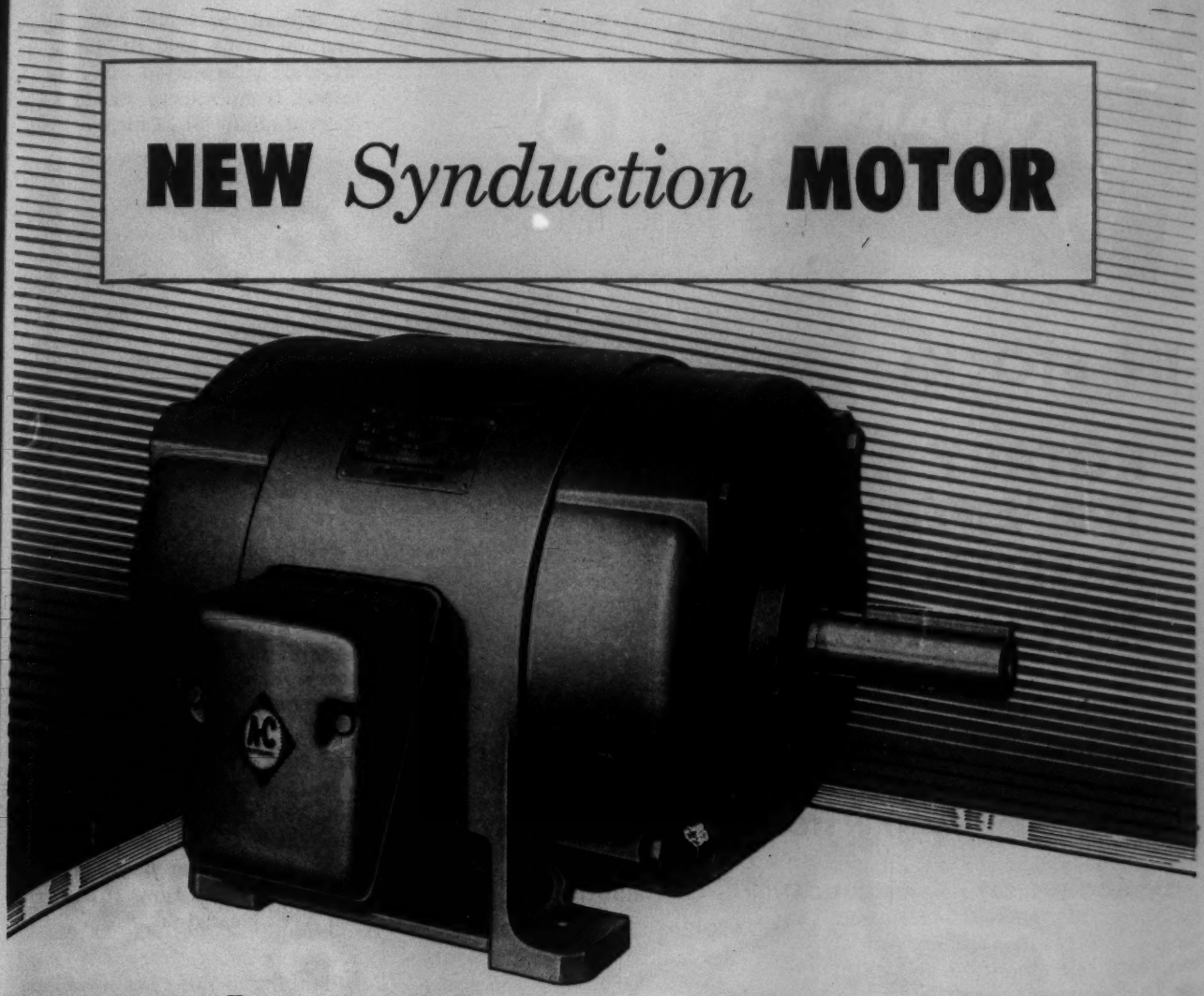
Oct. 18-20—
Foundry Equipment Manufacturers Association Inc. Thirty-eighth annual meeting to be held Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from C. R. Heller, One Thomas Circle, Washington 5, D. C.

Oct. 20-23—
Conveyor Equipment Manufacturers Association. Annual meeting to be held Greenbrier Hotel, White Sulphur Springs, W. Va. Additional information may be obtained from association headquarters, One Thomas Circle, Washington 5, D. C.

Oct. 22-24—
Purdue University. First Conference on Manufacturing Automation cosponsored by *Automation* Magazine. Additional information may be obtained from Editor, *Automation*, Penton Building, Cleveland 13, Ohio.

Oct. 22-25—
Society of Industrial Packaging and Materials Handling Engineers. Eleventh annual protective pack-

NEW *Synduction* MOTOR



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. . . Adjustable speed with minimum variation at any speed setting.

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aging and materials handling exposition to be held St. Louis. Additional information may be obtained from society headquarters, 30 N. LaSalle St., Chicago 2, Ill.

Oct. 22-26—

National Industrial Exposition & Management Conferences. Jointly sponsored by industry, labor, finance and government agencies in co-operation with the U.S. Dept. of Commerce and Defense to be held Detroit. Additional information may be obtained from A. F. Denham, 927 Book Bldg., Detroit 26, Mich.

Oct. 29-Nov. 2—

Western Reserve University. First of series of three seminars on effective management of recorded information to be held Cleveland. Additional information may be obtained from School of Library Science, Western Reserve University, Cleveland 6, Ohio.

Oct. 30-Nov. 1—

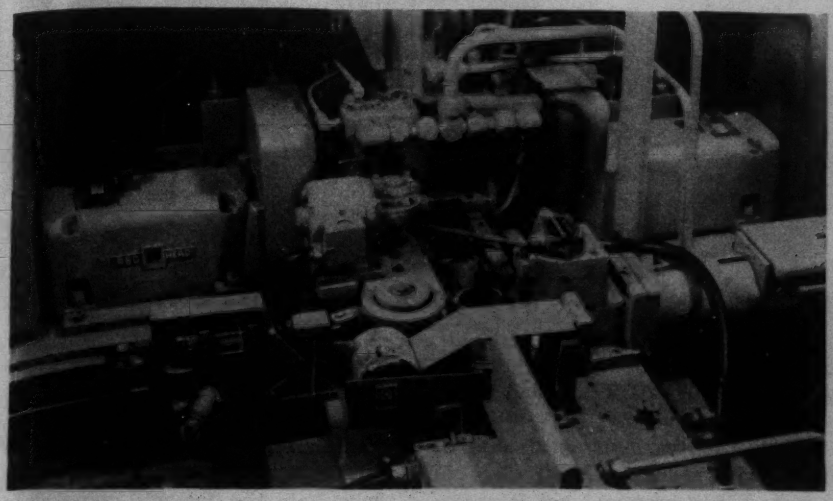
National Fluid Power Association. Fall meeting to be held Hotel Cleveland, Cleveland, Ohio. Additional information may be obtained from Barrett Rogers, 1618 Orrington Ave., Evanston, Ill.

Nov. 7-8—

Process Data Handling Symposium. Sponsored by Philadelphia Section, Instrument Society of America to be held Bellevue-Stratford Hotel, Philadelphia. Additional information may be obtained from Horace Richter, Fischer & Porter Co., 29 Bala Ave., Bala-Cynwyd, Pa.

"Now then . . . . Each wife has a card . . . ."

By JAMES C. KEEBLER
Associate Editor



Heald machine for boring pistons includes tooling that provides for orienting, handling, clamping, cutting, and gaging the parts. Loading chute attaches to trough where piston is shown in horizontal position. Behind this is the orienting device and to the rear of that the work station.

Tooling Automation

HARVEST time on the farm and harvest time for the tooling programs of Detroit both produce their share of headaches, long workdays, and pride of accomplishment. New-model programs that were long ago dreams of the process engineers and master mechanics are now in the make-it-run stage.

Some call it "debugging" others "proofing" and often it's known as the "pilot-lot." ("Pi!e the lot of 'em over there and we'll try some more.") In any event its a time when you've got to have parts and the new ideas are either bearing fruit or fizzling failures.

Men Behind the Men

As new methods to manufacture new parts become established the oft-sung heroes are the process engineers who establish the sequence of production operations. These are the "how-to-make-it" boys that are spearheading the ever-increasing automation offensive. But there's more to success than strategists and assault platoons. The processing engineer's efforts to devise good production processes, utilizing automatic machine tools and tooling, will win no victories un!ess backed by tool engineers who can transform the plans into workable tool designs.

Tooling Plan

Tool engineers (whose humble origin was in drafting drawings to record what the toolmaker had worked out) are putting their ideas on paper so that tools can be bui!t to their prints, and in so doing are contributing tooling plans, fixture layouts and tooling details to the automation program.

In making up a tooling plan for a given factory routing each machining operation must be provided with: (1) Jigs, fixtures or dies that support or restrain the part while the operation is being performed, (2) cutting tools or punches that do the actual work on the parts, (3) gages to check that the operation was done properly, and (4) handling devices to move the pieces to and from this operation.

Before automation thinking entered tool planning, jigs and fixtures were mostly hand operated. Now, the trend is to have a motion of the machine tool either operate the fixture directly or trip the control mechanism that actuates the air or hydrau!ic cylinder or electric motor that operates the fixture.

Cutting tools have been mechanically held in machines for years, but fear of downtime with automated equipment has led to designs that provide for quick change of dull tools.

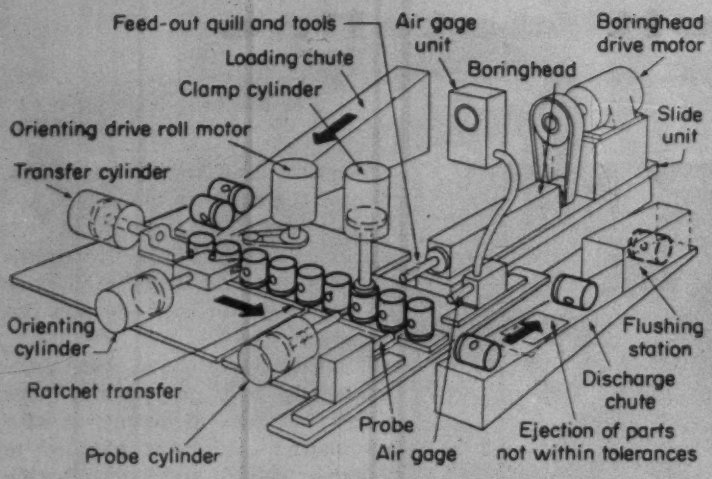
Gage planning has always presented a compromise, based on the tool planners judgment, between the critical nature of certain dimensions and the expenses for gages and inspectors' time. New thinking in the age of automation requires consideration of feedback gaging to correct machine settings, and gages to prevent jamming of automatic mechanisms.

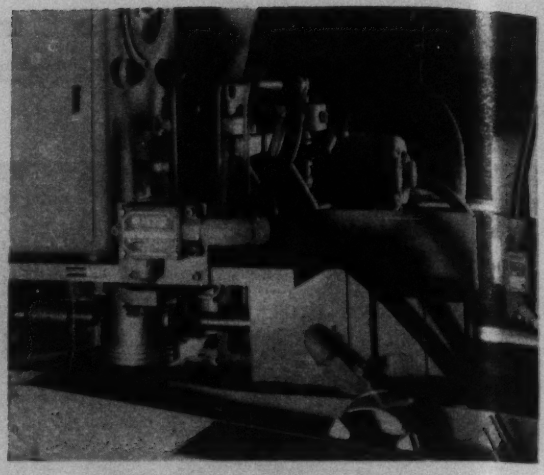
As automation techniques developed, tool planners saw the need to include hand!ing devices on the list of tooling to be considered for each machining operation. Hand loading and unloading is inconsistent with the efficient utilization of productive manpower. Basic handling equipment can be provided with special fingers, pawls, or hooks that make it adaptable to different production parts.

Air Lift

Use of air power is growing. To glimpse the large part this phase of automation is playing in automotive production operations, it is interesting to look at some comments concerning the Buick stamping plant by Edward Ragsdale, general manager of Buick and vice president of G.M. In this plant compressed air is used to lift nearly 700,000 pounds of steel parts every day—at the rate of 35,000 individual pieces a day.

"These mechanical hands and special transfer devices powered by compressed air are a big factor in preventing fatigue and increasing safety and efficiency of employees," Ragsdale said, "taking a lot of heavy lifting out of





Sketch shows relative positions of the functional mechanisms in the Heald automated piston boring machine. Close-up photo of the gaging station shows specific tooling for this application.

operating the stamping presses."

He points out that on one job alone—stamping primary pump covers—iron hands do about 30,000 pounds of lifting each day. Before this handling equipment was installed, the press operators had to do that job, lifting the stamped parts out of the press and placing them in stock tubs for transfer to the following operation. Now the iron hand grabs the part after stamping and places it on a conveyor that takes it directly to the next machine.

"Buick uses more than 21 billion cubic feet of compressed air every year," Ragsdale added, "and we anticipate even greater usage in the future as more mechanical helpers are designed to give employees a hand on heavy jobs."

Details, Details, Details!

Once a tooling plan is established for each operation of a manufacturing process the tool design work begins. Tool design layouts are approved and the details are drawn. Detailing is an important detail of the program. Probably no one has bothered to count the total number of tooling details in a 350-foot long transfer machine that performs 555 operations on V-8 cylinder blocks, but everyone involved in the program is aware of the fact that if one detail should be such as to interfere with the action of a clamp, or prevent loading or unloading of the workpieces, or be too fragile to accomplish its assigned purpose, then there's been a bug designed right into the tooling and no amount of care on the part of the toolmaker or tool inspector will get it out.

But on that fateful occasion of the pilot lot the sting of this bug will be felt. And the process development crew or master mechanic's troubleshooters will need more than a bug bomb to get things going properly.

Certainly the automakers are looking for tool engineering talent (there's no substitute for talent) that doesn't design bugs into the tooling so that the cost of exterminating them can be applied to progress of another sort. Tool engineering personnel must know their machine tools, how they cycle and how the various tooling components they are designing can tie into the machine with maximum safety and efficiency. Often a knowledge of pneumatic, hydraulic, and electric circuitry is required.

Due to the complex nature and seasonal aspects of the tooling programs the automakers do not maintain tool design groups of sufficient size to handle the complete chore. Assistance is sought from tool design shops and from the machinery builders—organizations with the background and experience necessary to tool up for automation.

How much of the equipment involved is new and how much is tied to existing facilities is a large factor in establishing the amount of co-ordinating effect that is required on the part of the processing engineer. If the program involves a new transfer machine to completely process the part in question, the machine tool builder who gets the job will most likely be asked to supply a machine that is fully tooled and tested with sample parts prior to shipment.

Standardization Set Back

In discussing automation's effect on jigs and fixtures, Henry M. Adams, an automation specialist at Chrysler, points out that the trend today for the machine tool builder to completely tool the new machines has reversed some auto firms' former trends toward company standards on jig, fixture, gage and cutting tool components.

Now they take whatever standards (if any) the machinery builder has established to simplify his tool design. The complexity arising when machine tool builders sublet the tooling design to tool design job shops gives user standardization another kick in the rear. The automaker is assured of a workable machine but any similarity between the tooling concept used here and that applied on the equipment across the aisle is solely the result of whatever co-ordinating effort he cares to apply.

Adams says the pendulum is going to swing back and cites the Plymouth engine plant as a new installation where tooling standardization yielded economies.

Whatever the per cent yield in successful tooling during model change pilot lots it is obvious that the old tool design note: "File and fit to suit" is not adequate for the age of automation.

Raise the Barriers

EXPERIMENTS in applying automation techniques in many plants today are such as to offer management little factual basis for evaluation. Like the blind men in the well-known fable of "The Blind Men and the Elephant," most attempts at automating are confined to a small area limited by experience and understanding. Dollarwise, results are equally restricted.

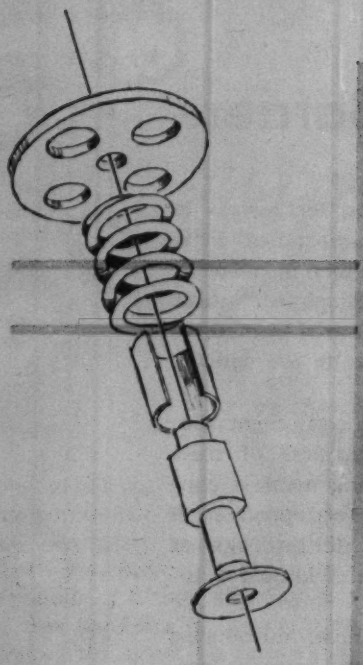
Basic economics in developing automated equipment dictate careful study of available methods regardless of their original purpose. And, while production management is constantly seeking answers to demands for improved production levels, quality and economics, certain factors militate against ready attainment of such aims through the use of known automation techniques.

Manufacturing today is a complex business; automated manufacturing more so. This very complexity raises a tremendous barrier to complete and thorough knowledge. Again, those most experienced and successful in the field of automated equipment most often are known only to the few. Finally, the cross-breeding of successful know-how across industries is an idea basic to American enterprise but one that actually remains almost unrecognized as a potent manufacturing consideration. It is of primary importance in automation.

Continuous advance into automated production is a must if steady progress toward improved manufacturing methods is to be maintained. To aid in creating a firm practical basis for evaluation and planning by production executives, AUTOMATION is cosponsoring with Purdue University "The First Conference on Manufacturing Automation." Here, a group of outstanding automation authorities, speaking from broad practical experience, will provide a realistic insight into manufacturing automation technology today. Gathered under one roof will be the greatest wealth of intimate knowledge on the subject ever assembled.

From a basic twofold approach, the papers will delve into a broad range of actual installations, the economics, the organization problem, the new concept of manufacturing planning, the product design influence, the plant, the equipment and, finally, how to go about accomplishing the job. This carefully integrated series of papers can lay the solid foundation for future development.

EDITOR



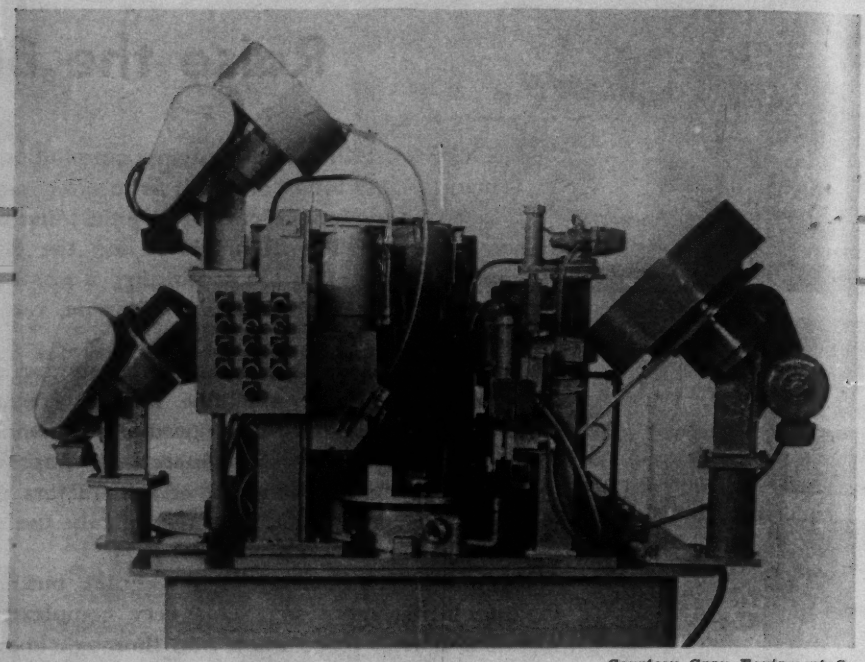


Fig. 1—Eight station assembly machine by Gray Equipment Co. puts together, counts and identifies valve assemblies consisting of five parts. Sketch shows parts and sequence of operations. Photo of machine shows parts feeders, control panel and dial index table with work nests.

Courtesy Gray Equipment Co.

AUTOMATED ASSEMBLY—1

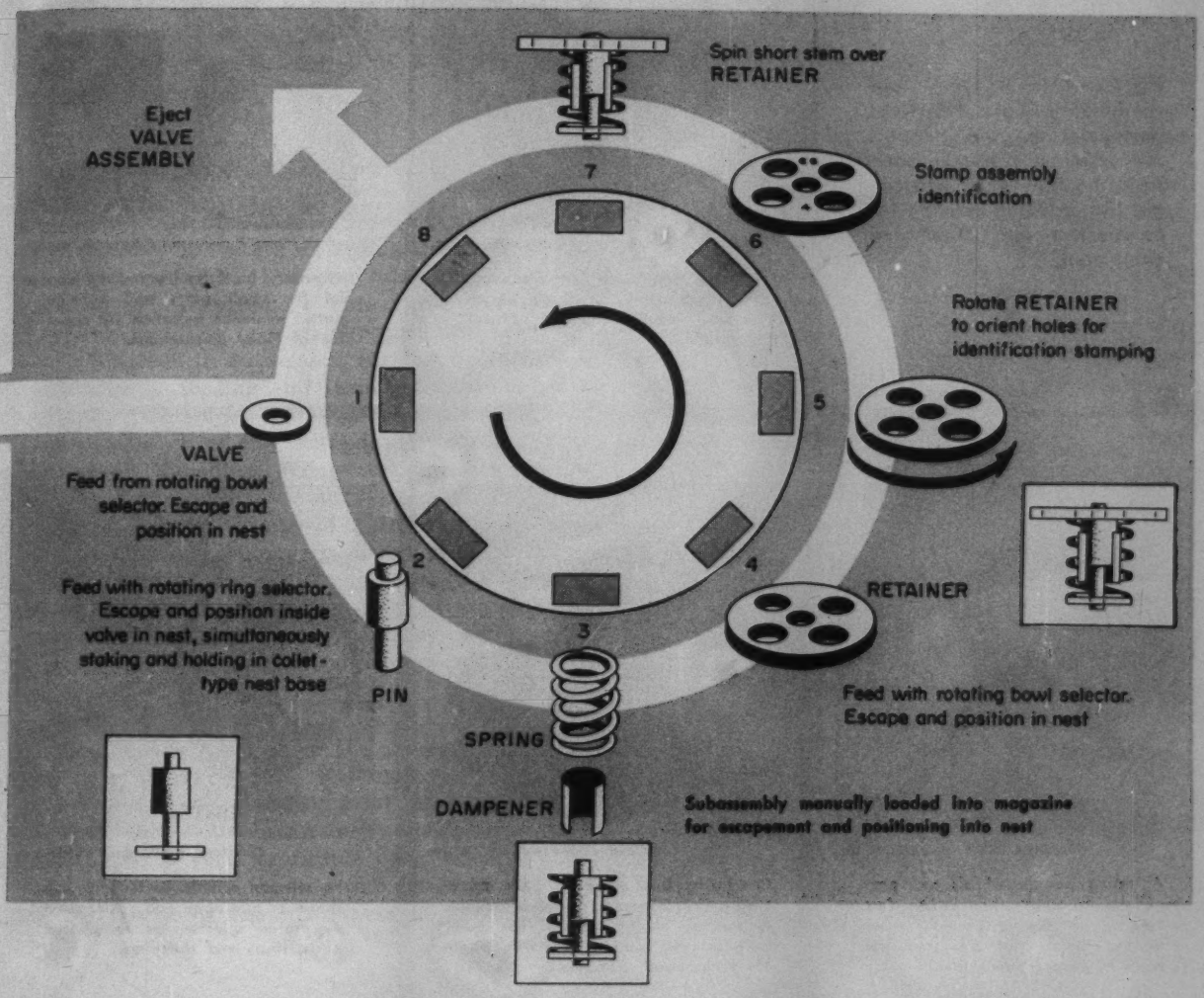
• BASIC CONSIDERATIONS

• PARTS FEEDING

By **KENNETH R. TREER,** Gray Equipment Co. Cleveland, O.

TABLE 1—Elements of Automatic Assembly Equipment

Parts Feeding	Transfer	Fasten	Sense and/or Sort	Eject	Control
Hoppers	Continuous processes	Coining	Probes	Random ejection	Mechanical
Parts-selectors	Transfer devices	Staking	Gages	Oriented transfer	Electrical
Magazines	In-Line Index	Riveting	Segregators	Packaging	Electronic
Orientation devices	Dial Index	Spinning	Markers		Pneumatic
Escapements	Transfer fixtures	Screw-driving	Coders		Hydraulic
Positioning devices		Nutrunning	Counters		Interlocks
		Welding			Feedbacks
		Special fasteners			


Spin short stem over RETAINER
Eject VALVE ASSEMBLY
Stamp assembly identification
Rotate RETAINER to orient holes for identification stamping
VALVE
Feed from rotating bowl selector. Escape and position in nest
Feed with rotating ring selector. Escape and position inside valve in nest, simultaneously staking and holding in collet-type nest base
PIN
SPRING
DAMPENER
RETAINER
Feed with rotating bowl selector. Escape and position in nest
Subassembly manually loaded into magazine for escapement and positioning into nest
1
2
3
4
5
6
7
8

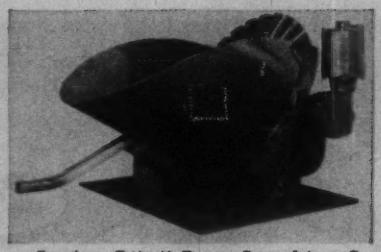
One of the greatest challenges presented to automation engineers of today is the reduction of assembly costs through the application of the principles of automation. Here in a three part article the author studies these requirements of the times.

AUTOMATION OF ASSEMBLY operations is a natural step in the century-old evolution of manufacturing processes. It is not a revolutionary step, but rather a logical and inevitable phase of manufacturing methods progress. A hundred years ago industry was already struggling with the problems of performing individual operations accurately and consistently enough to permit mass production of interchangeable parts. Machines and methods of all types had to be developed for each individual step in making a product to be able to produce it at all. As long as industry expands and new products are produced, these forming and fabrication problems will be attacked.

As mass production became practical, the emphasis changed from merely performing a specific task to performing many tasks with less and less labor to produce higher and higher quality products. Textile, chemical, food, automotive and other basic, highly competitive industries have led the way to higher degrees of automatic manufacture.

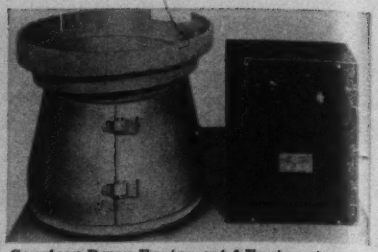
The combining of operations on one machine was one of the first improvements undertaken after basic manufacturing methods were worked out. About the same time came a "conveyorizing era" involving material handling from one hand-fed machine to the next. Today we are in an age of tremendous interest in fully automatic manufacturing where human effort is scheduled for merely the controlling and maintaining of long manufacturing sequences. The costs of accurate and consistent shaping, forming and material handling have been controlled to the point where assembly costs are the "sore thumbs" on the manufacturing cost distribution sheet. They would not stand out so if all of the answers were easy. This article will discuss some of these problems and available

Fig. 2—Various types and combinations of standard parts-selectors and hoppers are designed to handle parts from the bulk state into single file, oriented position for escapement into automated equipment.



Courtesy Detroit Power Screwdriver Co.

Rotating ring with large capacity stationary drum for large unsymmetrical parts requiring difficult orientation.

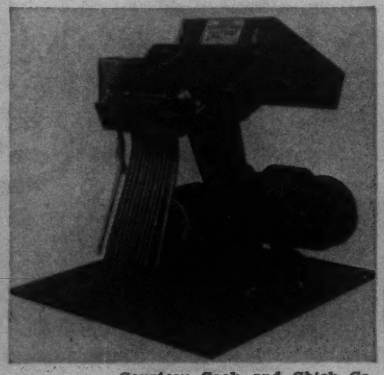


Courtesy Perry Equipment & Engineering Co.

Vibratory bowl type especially useful for small parts and delicate parts. Minimum agitation yet capable of many orientations.

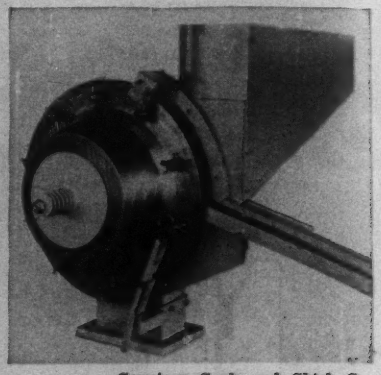
Courtesy Cook and Chick Co.

Agitating paddle wheels are part of the rotating drum. For fast feeding of flat disks and short headed parts that go onto the track in proper orientation.



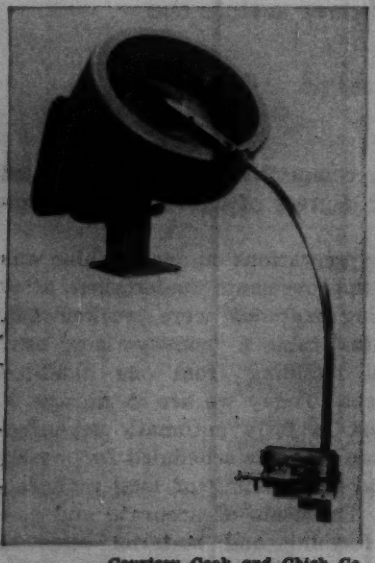
Courtesy Cook and Chick Co.

Oscillating box equipped with magazine and escapements for simultaneously feeding to 12 tracks. For balls, cylinders and headed parts with length 1½ times head diameter.



Courtesy Cook and Chick Co.

Pin-selector orients parts with cup shape or one open end. Also used as profile selector for shouldered parts, rings and stampings.

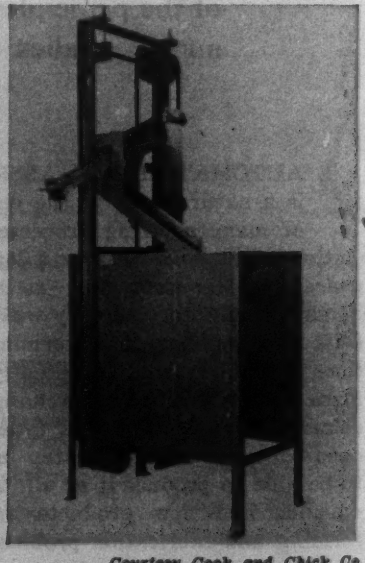


Courtesy Cook and Chick Co.

Selective orientation is function of shape of recess in ring that rotates in bottom of stationary drum. Used for pins, bushings, stampings, and irregularly shaped parts.

Courtesy Feedall Inc.

Elevating type brings cylindrical parts or sliding stampings up from bin to selector that provides automatic gravity feed.



Courtesy Cook and Chick Co.

Conveyor type with 6 cubic foot bin has elevator, track and escapement. Capable of one or two orientations on nonsymmetrical cylinders or stampings.

answers in parts 1 and 2, concerning the principles of automated assembly, and in part 3, will recommend a procedure for automating assembly operations.

General Considerations

Assembly machine development has been limited by a number of factors exceeding available equipment and methods. For one thing, high skill is required in an extremely wide variety of manufacturing methods to even approach the assembly field. Whereas in automated turning operations a knowledge of feeding and turning is required, for example, assembly work requires a knowledge of feeding plus all of the methods of fastening, fabricating and finishing. Where turning work usually involves parts of limited shape, size and material, assembly may cover anything from rubber parts through castings, stampings, screw machine products, springs, etc. A new type of machine builder is required—and is evolving—to take the skills of many fields and combine them into assembly equipment which will meet the requirements of the times.

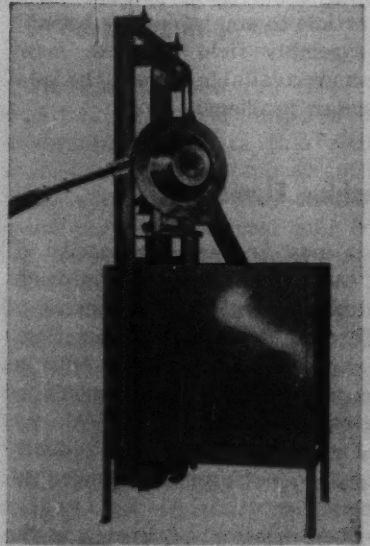
The practicability of automated assembly is frequently more limited by the company organization than by its product. For example, the status of the product design department may easily make the difference between an impractical automation project and a very profitable one. When a firm isolates its product design group from the disturbing influences of the manufacturing and tooling personnel; when the firm freezes its designs as originally conceived and when change requests for ease of manufacturing are considered "too costly" or a nuisance; it is to be expected that many operations will not be automated at all—and many that are will be accomplished at much unnecessary cost.

These are recognized facts which many firms are attempting to correct through training of design engineers in manufacturing practices and through establishment of intermediate engineering groups or product "grooming" departments.

Inventors, product engineers and design engineers approach their problems from the standpoint of function and appearance. It may be too much to expect them to consider all of the intricacies of manufacturing as well. In any case, the production engineers must have influence on product design decisions if the ultimate goal of optimum manufacturing costs is to be obtained.

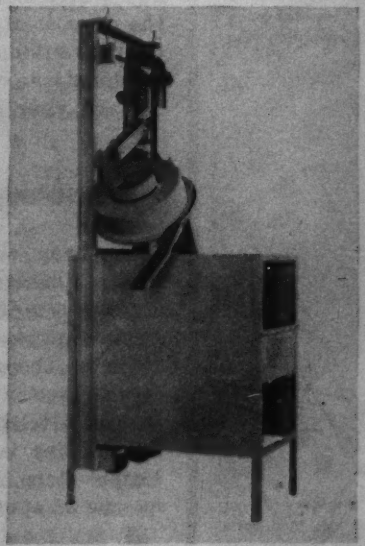
To obtain the higher quality of automated assembled products, a higher quality of raw components must be fed into the line. Hopper fed parts for example, must have a high degree of uniformity or the down time due to feeder jamming and the cost of scrap produced will quickly cancel the potential savings. Higher purchasing costs must be balanced against assembly labor savings and the advantages of higher quality end products. Where the required quality of raw materials is not available, inspection devices may be built into the assembly machine.

Equipment justification should acknowledge intangible as well as tangible savings. Product quality



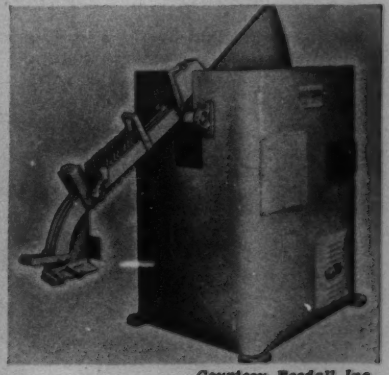
Courtesy Cook and Chick Co.

Combination of conveyor type with pin selector to accomplish difficult orientation of large quantities at high speed.



Courtesy Cook and Chick Co.

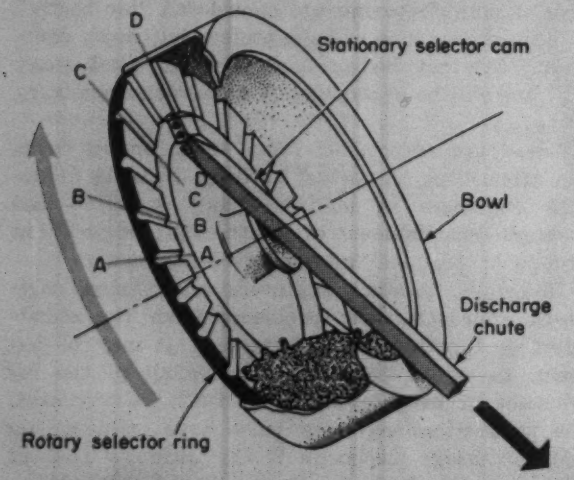
Combination of conveyor type with a rotating drum. Increased number of orientations possible. Capacity for large quantities.

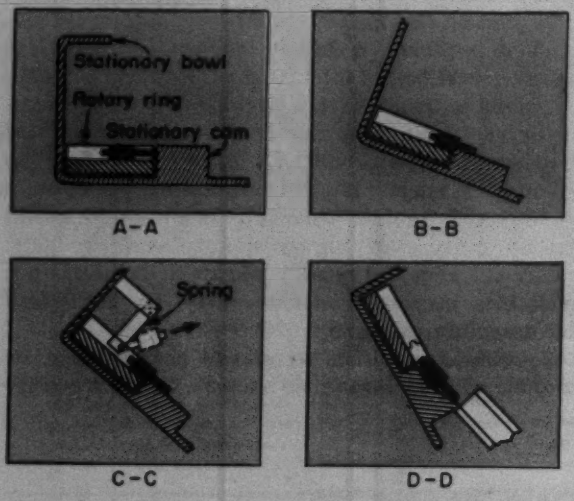


Courtesy Feedall Inc.

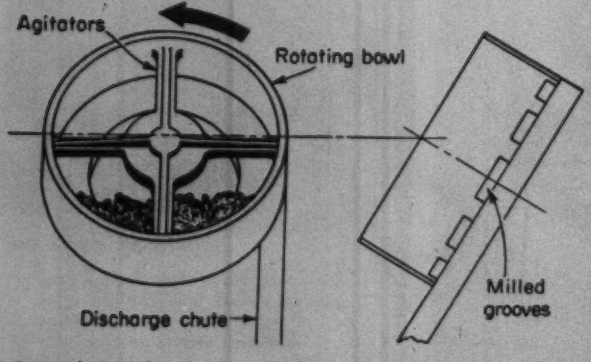
Oscillating blade rises through hopper to deliver spherical or cylindrical parts requiring fast feeding and minimum orientation.

Fig. 3—Sketches of the working principles of the parts selectors used on the machine shown in *Fig.* 1.



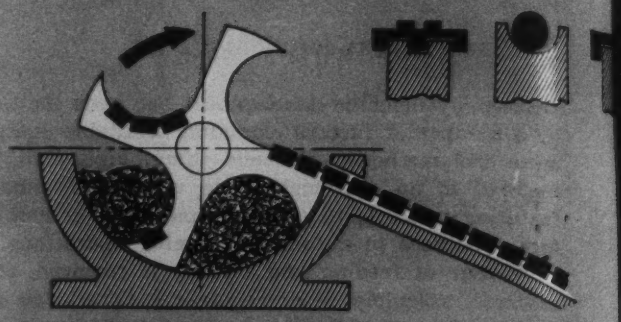


Parts-selector for pins. Stems are of unequal length. Because of this feature orientation is required. Two possible methods of selection are sketched. Section C-C shows a flat spring which snaps into each cavity as it passes, causing pins with the long stem up to flip back into the bowl. Section D-D shows a lift on the stationary cam which lifts only long stems releasing the large diameter from the cam stop and permitting the pin to escape to the discharge chute.



Parts-selectors for the brass valve and steel retainer are of the underfeed type which minimizes tumbling of the parts since they never travel up to the top of the bowl during rotation. The bottom face of the rotating bowl has milled grooves which will accept one part at a time. As the bowl rotates up past the discharge chute the parts drop into the chute or are refused and return to the bottom of the bowl. Agitators are part of the rotating bowl hub.

Fig. 4—Special feeder designs may be the ideal answer for special applications on parts of certain shapes. A few of the multitude of existing ideas are shown here.



Centerboard type is a version of the blade type of feeders. This one requires intermittent rotation. Handles irregular shapes.

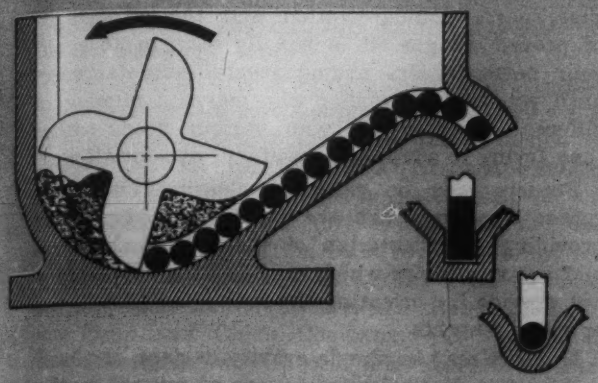
and uniformity, manufacturing standardization, upgrading of labor standards, decrease of supervision per unit manufactured, etc., are all definite benefits to be realized from automation. To reduce these factors to a formula is obviously a difficult, if not impossible task, yet these factors should have an effect on decisions involving automation projects.

Automation appears in many forms. To say "automation is okay for them, but it's no good for our product" is probably not a considered statement. Automation may cover the whole commodity from raw material to distribution or it may be an operational step covering just one phase of your business. The type of product, production volume and available methods must be considered. Whatever your product, it is almost certain that some profitable improvement in processing is practical and will enhance your competitive position. It is the purpose of this article to emphasize the breadth of the automatic assembly field and the many combinations of methods available toward the solution of your particular problems.

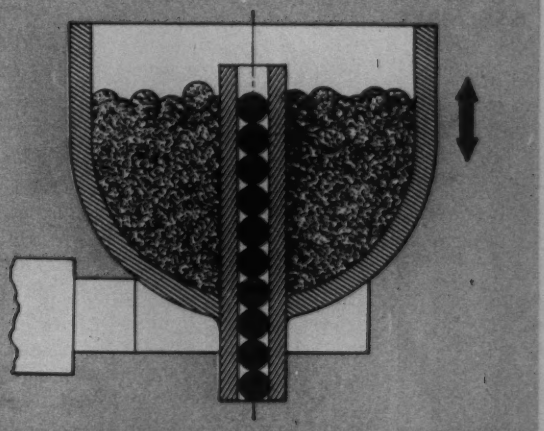
▶ Assembly Machine Elements

Six basic elements may be used to describe all of the functions of automatic assembly equipment —just as a time study separates the elements of human action performing a series of functions. Each of these six elements duplicates a type of human action. The most complex equipment, be it a dial telephone exchange or motor block machining line, is but a collection of many individually simple steps arranged to perform the desired sequence of operations.

TABLE 1 outlines these assembly elements in the general sequence of their application. Listed below each element are many of the methods used to perform that specific type of operation. This table is intended to emphasize the wide variety of meth-



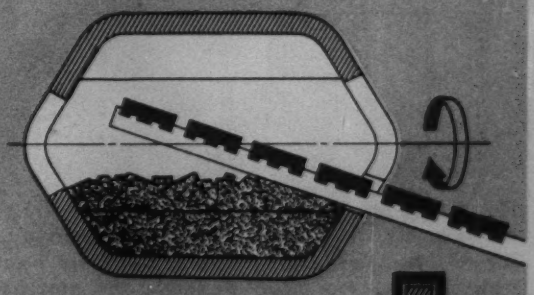
Paddle-wheel is another version of the blade type using continuous rotation. Best for disc and spherical shapes.



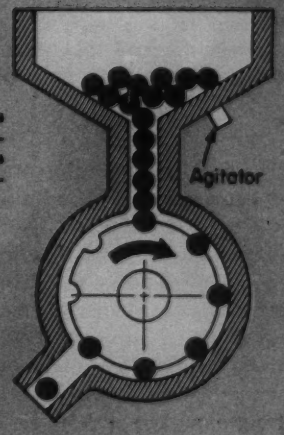
Tube type of feeder uses a stationary tube through a hopper which oscillates vertically. Commonly used for balls and cylinders.

ods available to do the various jobs. In preparing an automated assembly project careful study of the product and available facilities with respect to the many methods listed, should be made. Each of the elements will be briefly discussed and illustrated in the sections following for the purpose of suggesting the variety of standard methods available to the prospective user.

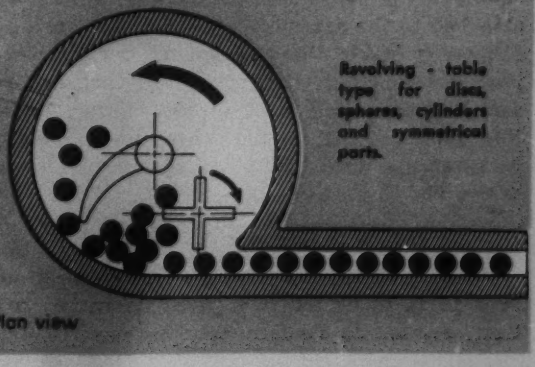
To illustrate a few of the elements and methods outlined in TABLE 1, assembly of the valve shown in *Fig.* 1 will be used as an example. This is a typical example of "operational automation." The many factors of technical and economic limitations in the automation of this product will be discussed under the various elements which follow. The resulting machine required to perform this assembly under these limitations is shown and will be studied.



Rotating barrel feeders may be used for headed parts, stampings and other irregular shapes. Large in size; will handle wide varieties of sizes.



Rod-feeder for long rods or tubes. The escapement may be the fixtures or spindles of the machine.



Revolving - table type for discs, spheres, cylinders and symmetrical parts.

Plan view

▶ Parts Feeding

Probably the best rule to consider when feeding a part is not to lose control of it from the previous operation. Simple as this sounds, it is usually overlooked. Tracks, tubes, special conveyors and many other devices may be used to transport oriented parts at less cost and trouble than refeeding and reorienting. A good example is a continuous valve processing line on which automotive engine valves are carried, hanging by their heads through roll straightening, stem grinding, seat grinding, etc. without losing their orientation or being hand positioned throughout. One parts-selector at the beginning of the line gives the original orientation.

Where previous operations involve excessively bulky equipment, such as large presses, or where it might be necessary to excessively slow down either the assembly machine or the previous machine to match speeds; it becomes impractical to tie together the operations and refeeding becomes the more economical method.

Where a part may be easily fabricated from raw

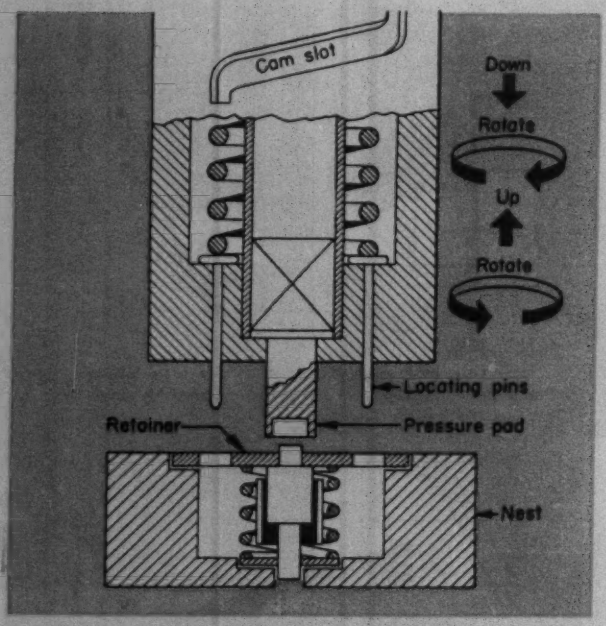


Fig. 5—Special orientation device used to orient the retainer in *Fig.* 1 to permit stamping the part assembly identification numbers between the retainer holes. In operation the tool head descends, the pressure pad engages the retainer around the unfastened pin to prevent mislocating the retainer as the tool retracts. The spring loaded locating pins engage the retainer at any point—compressing their spring if not in the holes. When sufficient pin length is down to pass through the holes, a pin in the cam slot rotates the whole tool to a given point. The width of the cam slot permits the tool to retract the locating pins before returning to the starting radial location.

stock, such as a light stamping or gasket, the most economical method may be to install a fabricating unit directly on the assembly machine, assembling at the end of the fabricating stroke or cycle. Vacuum pump diaphragms, for example, may be punched, blanked and inserted into the assembly in one device directly from reel stock. Another example of this method would be the coil spring shown in *Fig.* 1. The tendency of these springs to tangle makes a hopper feeder impractical and enhances the value of an automatic spring winder attached to the assembly machine. The spring steel dampener inside the coil spring complicates this problem. However, until the dampener can be redesigned to permit its hopper feeding and insertion into the coil spring, this sub-assembly will be manually loaded into a magazine feeder which is not shown in *Fig.* 1.

Hoppers and Parts Selectors

Where neither fabricating nor retaining control over parts to be fed to a given operation is practical, automatic feeders may be selected from a broad group of standard feeders. Obviously, it is best to select a standard design of feeder rather than a special unit for reasons of procurement time, parts standardization and the advantages of proved designs. It is equally wise to shop for your parts feeders among several manufacturers until you find a supplier who makes a number of different types to suit your various needs rather than trying to adapt one specific design for all uses.

Feeders may be generally classified into two types: Hoppers which are usually bulk dispensers providing no orientation of the individual pieces, and parts-selectors which may be of a hopper type but provide for orienting the individual part in one or more respects.

Hoppers may be simple gravity devices, mechanically agitated or vibrated by one of several means. This is particularly true of bulk materials which tend to pack or jam at the discharge or chute. Other types of hoppers utilize continuous conveyors which lift parts from the bottom, up over the side and provide their own agitation.

Parts-selectors, as such, provide for accepting or passing only properly oriented parts, or in some cases, causing the part to orient itself. Parts-selectors may contain the hopper in their own design or they may be fed by hoppers. Almost all parts-selectors use gravity to cause the parts to orient themselves after being agitated by mechanical or vibratory means. Neither the mechanical nor the vibratory principles are satisfactory for all applications. Each type has its own limitations and must be considered competitively in the light of the job to be done.

Illustrated in *Fig.* 2 are many of the currently available types of hoppers and standard parts-selectors. The general uses of each are outlined with each illustration but the proper application of each type should be specified by the manufacturer.

The valve assembly machine in *Fig.* 1 utilizes two basic types of automatic hopper-type parts-selectors. The valve and the retainer both use the rotating bowl type of parts-selector. Milled recesses on the bottom face of the rotating bowl permit one part at a time to slip into the recess. As the recess passes the delivery chute these parts drop into the chute or back into the bowl if the chute is full. This might be called an under-feed type of hopper since the parts are discharged or rejected as the bowl rotates upward. There is no need for the parts to be carried up to the top of the bowl's rotation. Naturally this minimizes the the tumbling of the part and offers a much more satisfactory parts-selector where applicable. Two sizes of the rotating bowl parts-selector are shown, a 9-inch bowl for the tiny brass valve and an 18-inch bowl for the relatively large retainer. This type of parts-selector also works on certain headed parts and those having a distinct cross-sectional profile.

The brass pin is automatically oriented and fed into this assembly machine with a rotating ring type of parts-selector. This is desirable since the

parts must not only be oriented axially, but with the proper end down. *Fig.* 3 illustrates the action of the rotating ring parts-selector on the brass pin as well as the rotating drum parts-selectors on the valve and retainer.

Special parts-feeder design requires a peculiar talent—and not a common one. Most feeders which are parts-selectors, operate on the principle of gravity and the probability of a given shape falling in the same manner a given percentage of the time. Visualizing this effect and the required hopper shape and action calls for a different approach to the problem than that used by most machine and tool designers. Mr. Bates Cook, of the Cook and Chick Company, has commented that the easiest way to design a feeder is to mentally crawl inside and imagine what you would do if you were one of the parts! This is not all humor—and not all of the job. Once the feeder is designed, much of its successful operation is due to the skill of the assembler who grooms it to maximum efficiency.

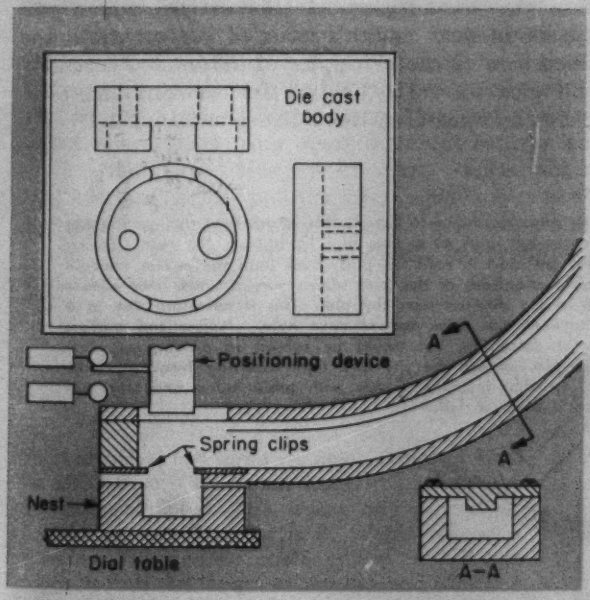
One of the more common mistakes of the inexperienced hopper designer is to make it too complicated. There are enough complications in automation without adding to them. If the feeder principle cannot be kept extremely simple, it is usually better to consider product design changes or manual handling. *Fig.* 4 illustrates a few special parts-selector designs.

Percentage of efficiency in parts feeders is important. Feeders based on free-falling, tumbling or vibration work on a percentage basis. If one orientation is required (one of two possible positions of the part in the track) it appears that twice as many parts as required at the delivery chute must be picked up. This is not entirely true, since the law of averages is only an average; there will be times when parts will fall the wrong way consistently for an extended period of time, and more than twice as many parts must be picked up to guarantee satisfactory operation of the assembly machine. This increase may be minimized by providing a bank, or storage space in the track, but as the number of possible positions increases (three orientations require picking up eight pieces to get one right) orientation devices may be required to obtain sufficient output.

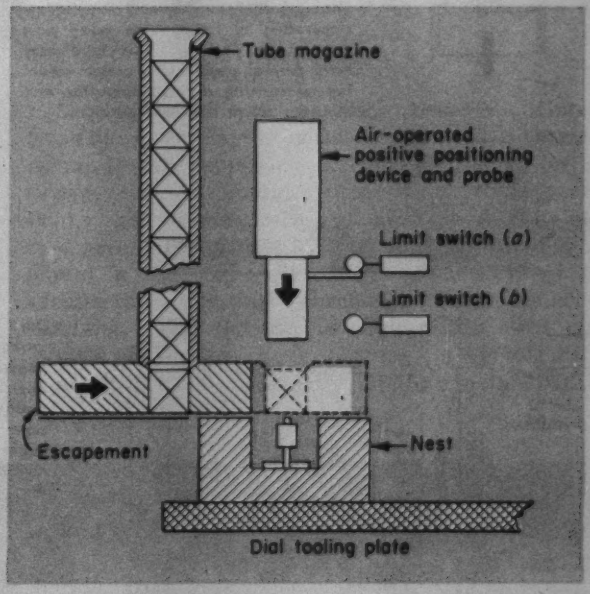
The retainer in *Fig.* 1 requires a special orientation after it is placed in the fixture to permit stamping the part number between any two of the four holes. This device is shown in *Fig.* 5.

Feeder costs have natural limitations. They are used to eliminate the cost of hand labor or to increase the rate of operation beyond the human capacity to feed. If an added operator is less ex-

Fig. 6—Magazines may be designed for almost any shape of part. Illustrated are two types which free the operator from direct timing with the assembly machine and provide a safety factor in keeping his hands away from moving parts.



Track-type magazine for die cast parts which require orientation in two ways. Automatic selectors could be designed, but cost would prohibit use in this application. Operator orients bodies for proper side up and proper slot end forward. Key in top of track maintains orientation as does key in positioning device. Space under positioning ram is adjusted to hold one part. Spring clips prevent part dropping until ram is actuated by table index. Limit switches interlock ram and table index as well as shutting off machine when magazine is empty.



Tube type magazine for the coil springs in the assembly in *Fig.* 1. Springs are ground-end making simple the aligning in the tube. Also shown is the simple slide-type escapement which transfers workpieces one at a time to a position over the nest. Considerable length variation is permissible when the slide is relieved to push up the second spring which might try to enter. The air-operated positioning device is impulsed by the slide which is in turn impulsed by the table index. Limit switch *A* permits the table to index when the positioner is up. If no spring is inserted, positioner actuates limit switch *B* which can either stop machine for operator attention or reactivate the escapement if desired. Operator can feed tube magazine about twice as fast as the machine cycles permitting some spare time for other duties.

pensive than the feeder, all things considered, it will be very difficult to convince management that it is a wise expenditure. Since few parts-selectors cost less than $500, and few operators cost more than $5000 per year, the range of practical expense is rather well defined. Occasionally feeders for large parts, or large quantities of parts may justify more than human labor, and each job must be considered on its own merits.

Volumes could be written on feeder design and application. Actually very little is published, not for lack of knowledge or desire to disseminate the information, but because of the tremendous number of variables involved in selecting the proper unit. We would suggest that the best method of handling this phase of automation is to establish and maintain contact with experienced suppliers in this field. New ideas and fresh approaches are daily events in this, one of the oldest fields of mechanical effort.

Magazines

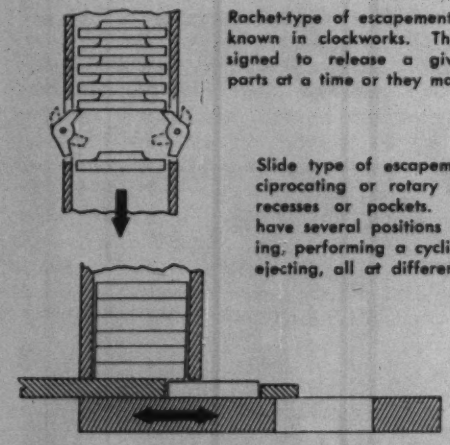
Magazine feeds have long been used to free the operator from direct timing with his machine where fully automatic loading is not practical. Usually this results in some free time for the operator to perform additional duties, to add a safety factor in keeping the operator's fingers away from the machine, or at least, to remove some job tedium and fatigue. Difficult orientations are frequently resolved manually with these methods. It might be said that magazines compromise between the cost of complicated feeding devices and the high production required at an economical price. *Fig.* 6 illustrates a magazine for parts which are impractical for automatic hopper-type parts-selectors as well as the magazine selected for the coil spring assembly referred to in *Fig.* 1.

Escapements and Positioning Devices

Whether hoppers, parts-selectors or magazines are used, some type of escapement is usually required on most cyclic machines. An escapement is essentially a measuring device. In the food industry the escapement may meter out a given amount of granular or liquid material, while in the automotive field, the escapement will release one or more parts to a fixture, usually in oriented position. Escapements may be separate units by themselves, they may be incorporated into the positioning device, or they may even be the fixture itself. As in all phases of automation, the simplest method is usually the best method with the least maintenance and complications. *Fig.* 7 illustrates both escapement and positioning devices.

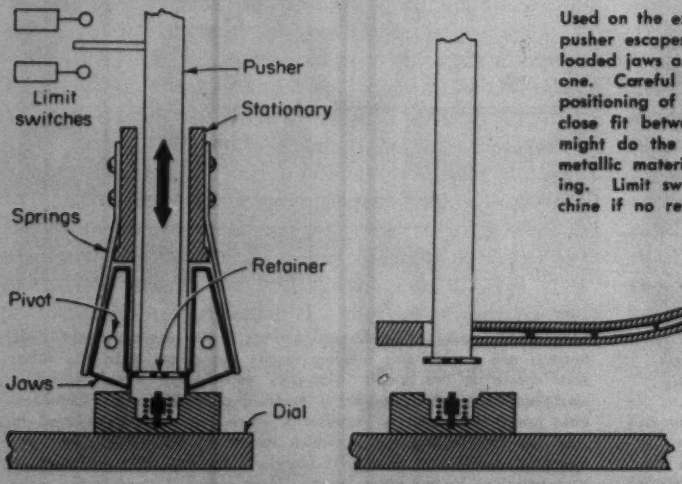
The positioning device is used to transport the work piece from the track, magazine, etc., to the fixture, nest or work area. Where precision location, probing, gaging or other special functions are required, the positioner may serve the purpose.

In the second part of this article, which will appear in next month's issue of AUTOMATION, the discussion of the principles of automated assembly will pick up with the transfer element and complete the remaining items listed in TABLE 1.



Rachet-type of escapement most commonly known in clockworks. These may be designed to release a given quantity of parts at a time or they may be adjustable.

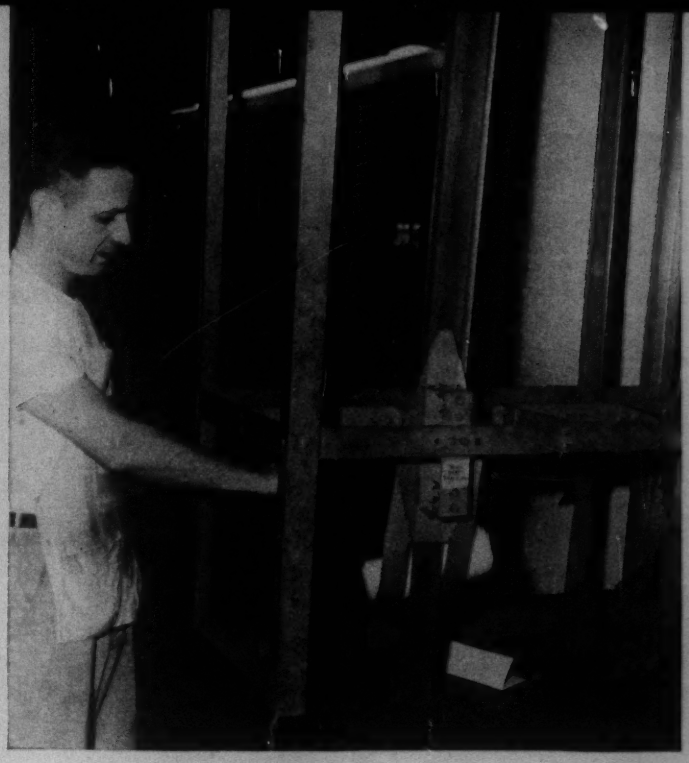
Slide type of escapement may be reciprocating or rotary with many part recesses or pockets. This type may have several positions to permit escaping, performing a cyclic operation and ejecting, all at different positions.



Used on the example shown in *Fig.* 1, this escapement and positioning pusher escapes one part at a time and holds back the rest. Spring loaded jaws are used to hold the parts back until the pusher removes one. Careful alignment of the jaws allows very accurate and square positioning of the retainer over the pin. This is necessary due to a close fit between pin stem and retainer hole. Magnetized pushers might do the same job, but would be subject to picking up other metallic material around the site and thus requiring frequent cleaning. Limit switches interlock pusher with table index and stop machine if no retainer is fed.

Fig. 7—Escapement mechanisms are designed to meter the flow of workpieces from tracks or magazines as required by the assembly machine. Actuation is usually by linkage with, or signal from, the index mechanism, and is closely coordinated with the positioning device.

1



Four separate Novak conveyor systems carry copy from its point of origin to the composing floor and proofs of copy from there back to news and advertising departments for checking. The conveyor consists of a rounded metal slide and a 2-inch wide canvas belt with two narrow protruding strips of rubber extending for its full length. The rubber strips touch the metal and copy placed between these strips and the slide is carried by friction at speeds up to 300 ft per minute. Each of these conveyor systems is two-way and entry points may be installed at any spot along its length.

AUTOMATION TODAY

HANDLING IN NEWSPAPER PRODUCTION

PUBLISHING a large daily newspaper calls for considerably more effort in the material handling line than might at first be realized. Considered in typically industrial terms, raw material in the form of both information and physical substances comes from many different sources and in a short time ends up at many thousands of destinations; it is apparent that a modern publishing plant would probably depend upon automation techniques in maintaining economy in production and distribution.

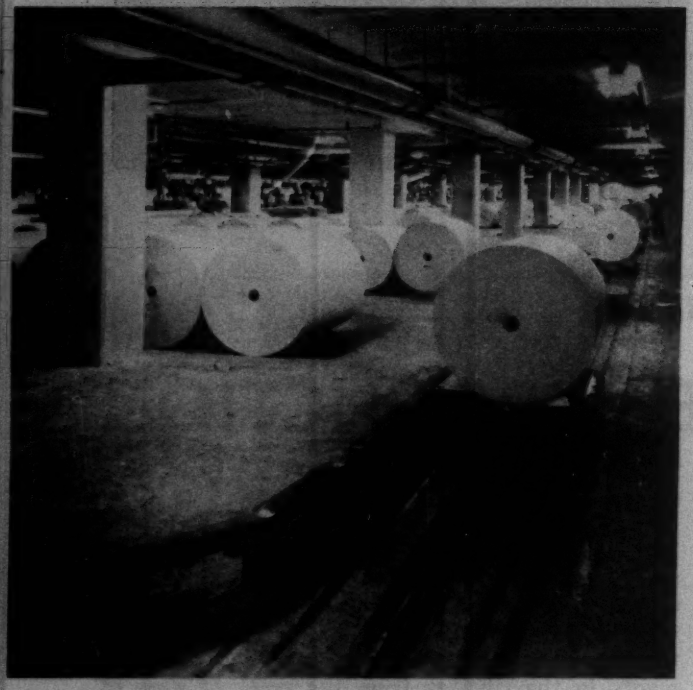
The new facilities at which the Philadelphia Evening & Sunday Bulletin are printed illustrate an up-to-date approach to the production of a newspaper. Automatic devices which could practically and economically be used were installed to make this one of the most modern newspaper plants in the country from the point of view of architecture, printing, warehousing and material handling. The Bulletin is equipped to turn out 245,000 papers per hour, although a typical rate is about 200,000. Its daily circulation is 715,000

2

Rolls of paper newsprint weighing between 1600 to 2000 lb are unloaded from freight cars by specially equipped fork trucks and placed on individual cars in a Jervis B. Webb Towveyor system. The endless cable system is 1/3-mile long: it runs the length of the railroad platform into and around a paper storage area, out to a reel room below the press floor and back to the railroad siding. System moves at a rate of 30 to 90 ft per minute, and was adapted from a similar system used in a wholesale warehouse. The illustration shows a Lewis-Shepard fork truck in storage area placing a roll on a cart headed for stripping platform.

3

At the stripping platform, rolls are weighed and the outer protective wrapping is removed. Air-operated levers automatically push the rolls from the Towveyor carts onto the sloped platform. After weighing, the rolls wait on the edge of the platform for the approach of an empty cart. As an empty cart approaches, it trips a lever which releases the chocks, permitting the roll to move onto the cart.



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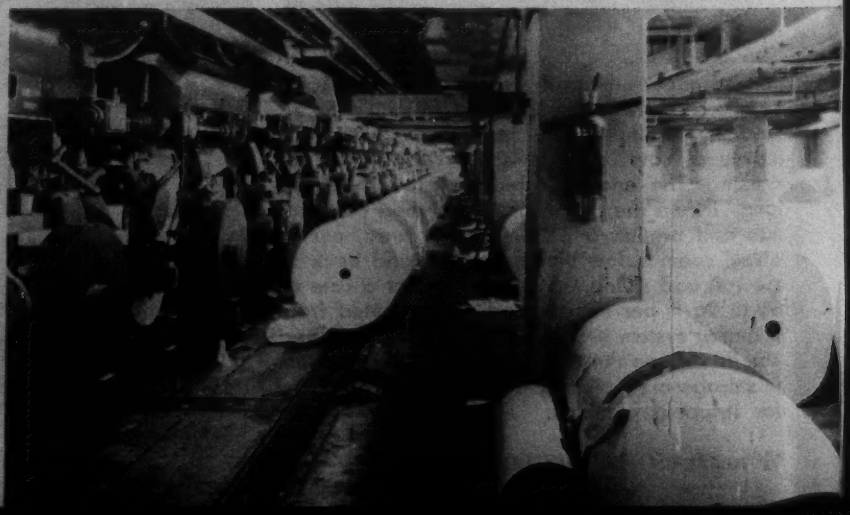
From the stripping dock, the Towveyor carries the rolls to a flat storage area adjacent to the reels located beneath the presses. The floor is sloped such that the rolls descend by gravity from the unload point toward the reels.

in eight regular editions, with over 730,000 on Sundays.

When the new plant was in the planning stage, Bulletin executives visited and studied not only other newspaper establishments, but also warehouses and offices in other mass production and handling fields in search of the best ideas and equipment. Some of the ideas put into use come from the newspaper field, but some come from wholesale grocery and drug companies after being adapted to a newspaper's special needs.

Any newspaper has to cope with four different general classes of materials—copy, both news and advertising; mechanical media of type, page forms, matrices, and stereoplates; raw paper in rolls; and printed newspapers. These four items, from the material handing standpoint, are examined in the accompanying photographs. Other areas where automation is in evidence could also be noted. As might be expected, the presses themselves represent the very latest equipment available. Presses and folders are electronically controlled and function with a minimum of human effort. The news gathering facilities represent latest advances in communication fields—including teletype press syndicate equipment and radio-telephone equipped cars for local news coverage.



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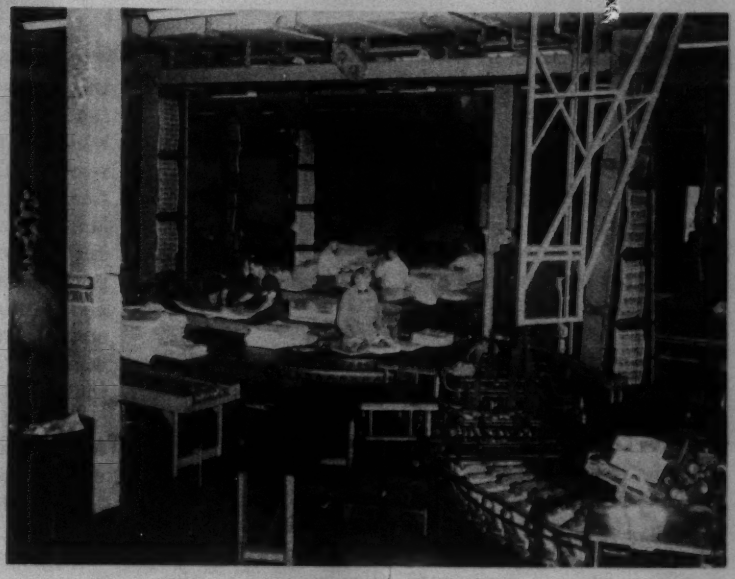
At the reel end of the flat storage area, individual rolls are pushed off the holding chock by hand onto a dolly and manually moved over a track system with turntable and switches to the spot where they are needed. Paper from these reels is fed to presses located on the floor above.

6

Curved metal stereoplates used for printing at the presses are conveyed from the stereotype foundry by a conveyor recessed into the floor. The conveyor consists of two roller chains. The plates ride on the top surface of the rollers. The three furnaces and casting machines in the foundry can deposit as many as 24 plates per minute onto the common conveyor. In order to prevent damage, by one plate landing on top of another, the system is devised so that each casting machine can deposit a plate only on certain sections of the conveyor. After runs, used plates are returned to the foundry by a return leg of the conveyor system.



7

Printed papers are carried from the presses up to the mail room by Cutler-Hammer conveyors. This illustration shows a general view of the mail room with part of this conveyor system in operation. Folded papers are delivered by the press conveyors to one of four U-shaped roller conveyor units. The ends of each U-shaped system lead to openings onto the truck loading dock. A Sunday paper consists of a typical daily paper plus the addition of various preprinted sections. These preprinted sections are manually fed into hoppers which drop them in order into pockets as the "stuffer" turns. Completely assembled papers are directed along the power-driven roller conveyor to the wrapping area.

8

In the wrapping area, papers are shown approaching a Signode wire tying machine. The equipment consists of an aligner, actuated by a photoelectric cell, which jogs the paper into an orderly pile and spaces the stacks; a device for putting the bottom wrapper under a newspaper bundle; a bundle feeder which feeds stacks of papers into the tying machine automatically; and the wire-tying machine which wraps a heavy wire around each pile and twists it into place. Except for the wire tying machine, the mechanisms shown are working models being tested in actual use prior to final development. From this point the papers are directed to the truck loading dock.

9

In the shipping area the papers are placed on a belt conveyor made up of separate reversible sections which run at right angles to the conveyor from the mail room. Bundles may be directed to particular loading point; each point is equipped with power driven roller conveyors with telescopic ends, made by Jampol Co., which lead to the trucks. On the conveyor leading to each truck is a counting device activated by the weight of the bundle passing over it which makes it possible to record the number of papers carried by each truck.

COMPUTING MIX PROPORTIONS AUTOMATICALLY

LITERALLY THOUSANDS of variations of grinding wheels are used throughout industry. Since grinding jobs vary so widely a great number of grinding wheel types are required. A grinding wheel specification has five basic elements, each having many variations. One manufacturer offers 20 kinds of abrasive, 25 grain sizes, 72 hardnesses, 17 different structures and 33 bond variations. A change in any one of the elements produces a grinding wheel with different characteristics. Compound these variables with variations in wheel size and number of wheels ordered and some of the problems of formulation become apparent.

Bay State Abrasive Products Co. has linked electronic computing equipment with a punched card system to automatically calculate formulas for manufacture of their grinding wheels, *Fig.* 1. Grinding qualities needed for a particular application are analyzed by an abrasive engineer. He then recommends a wheel specification that will furnish these qualities. The manufacturer calculates a formula for every grinding wheel specification. This formula tells the factory the ingredient proportions that will be needed to make a wheel matching the field engineer's specification.

With the new system, calculations that would occupy an entire department for a day under former methods are performed in minutes. The electronic system also performs these calculations with a consistent accuracy beyond human capacity.

First steps in the establishment of the system were taken at Harvard University Computation Laboratory, with the help of their Mark IV computer. Manufacturing increments in grinding wheel hardness and abrasive grain concentration were calculated along straight line progressions. These uniform series provide the constant basic data used for electronic calculation of formulas.

Fig. 1—In this installation, formulas for proportioning of grinding wheel ingredients are calculated from field engineer's specifications and constant basic data. Information is fed to the equipment on punched cards and orders for direct factory use are printed out on eight-part forms.

Steps in Operating

When an order for grinding wheels is received, the cards carrying the constant formula data are fed to the calculator. Then cards are introduced which carry such variable information as size of wheel, quantity of wheels ordered, customer identification number, product code, shipping data, etc. Manufacturing instructions detailing each ingredient and other notes are printed out on an eight-part form by the equipment. One of these forms goes directly to the factory as manufacturing instructions. The possibilities of human errors in manually calculating or transcribing are thus eliminated. Cards carrying the important data for each order are kept on file so that succeeding orders for the same grinding wheels will be formulated exactly as before.

An IBM Card Program Calculator with a storage unit performs the computing processes. Three completed formulas can be produced per minute, each involving 160 different calculations. Each calculation the equipment makes is automatically checked for accuracy. Calculations are carried out to six places.

As a supplement to this system the company has direct TWX communication with each of its branch offices in Chicago, Cleveland, Detroit and Pittsburgh. Orders come to the factory from the branches via TWX and are recorded on punched tape. The tapes are translated onto punched cards by a tape-to-card converter, and the cards are then ready to go into the calculating equipment for processing. When in full operation, the system will reduce from ten days to one day the time taken to get a branch office order into the company's factory.

Besides calculating grinding wheel formulas and printing orders, the system collects important data. The storage unit holds information on the quantities of raw materials used, and this data can be read out as needed. Marketing and sales statistics —types of products sold, types of customers sold, sales territory volumes—can be accumulated and preserved.

According to Bay State's management this system has many valuable functions, and they believe that in the not too distant future an electronic system will be applied to the manufacturing process to physically select, measure, combine and process the ingredients.

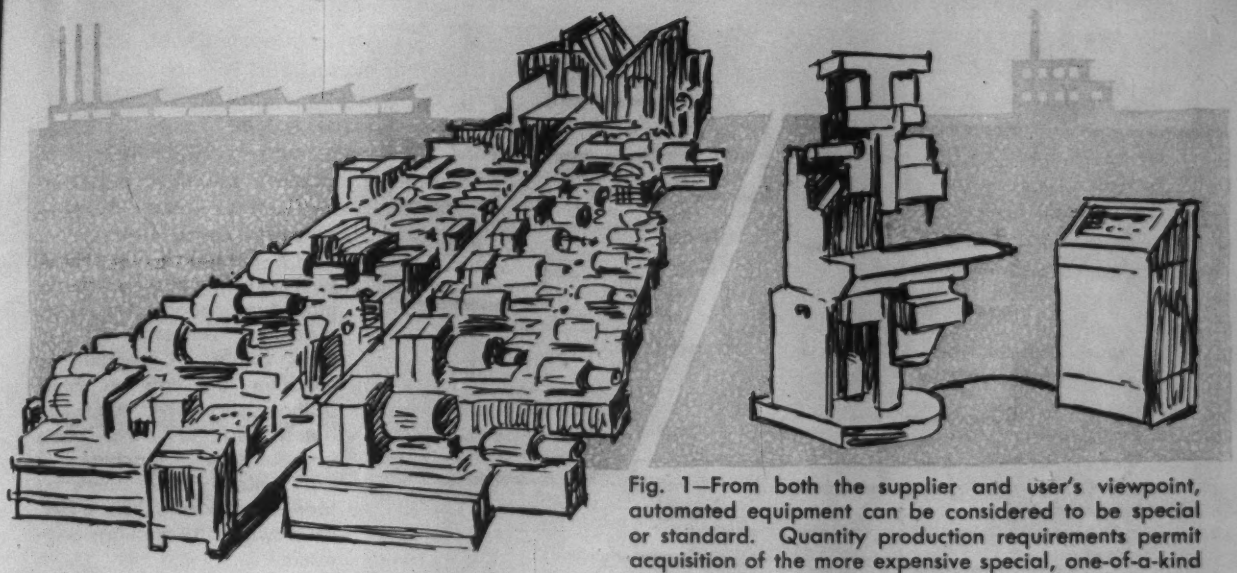


Fig. 1—From both the supplier and user's viewpoint, automated equipment can be considered to be special or standard. Quantity production requirements permit acquisition of the more expensive special, one-of-a-kind machine. Low quantity production requires low-cost standardized equipment suitable for versatile machining operations.

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TAILORING AUTOMATION TO PLANT NEEDS

To those managers of the smaller and specialized plants who are dissatisfied with their profit picture, but who have rejected automation as "not for them," this question is posed: What share of the prosperity of the future can the small company hope for as larger companies progressively increase production efficiency with upward spiralling profits based on previously attained efficiency? Regardless of the size of the plant, to compete in tomorrow's economy the answer is to continually review, search out and install the highest level of automation economically possible.

THE WORD AUTOMATION is one which in recent years has become an intimate addition to each businessman's vocabulary. We are constantly exposed to it in the literature we read, the conferences we attend, and in our everyday business activities. With this familiarity bred by continued usage we might begin to think of automation as denoting a particular or absolute condition or stage in technological development. We could create an absolute meaning of the word if we allow only that definition resulting from the most idealistic projection of the ultimate object—the "pushbutton factory," where the entire productive process is accomplished without human intervention or control. We would, however, have a word which (although sharply definitive) is useless in our vocabulary since it is probably safe to say no such productive effort exists or will exist for some time. In a general sense, automation is more of a philosophy than an absolute stage in industrial development.

The concept of the "pushbutton factory" can be useful, however. To gain insight into what our automated future might hold for us as managers and into what changes might be demanded of our

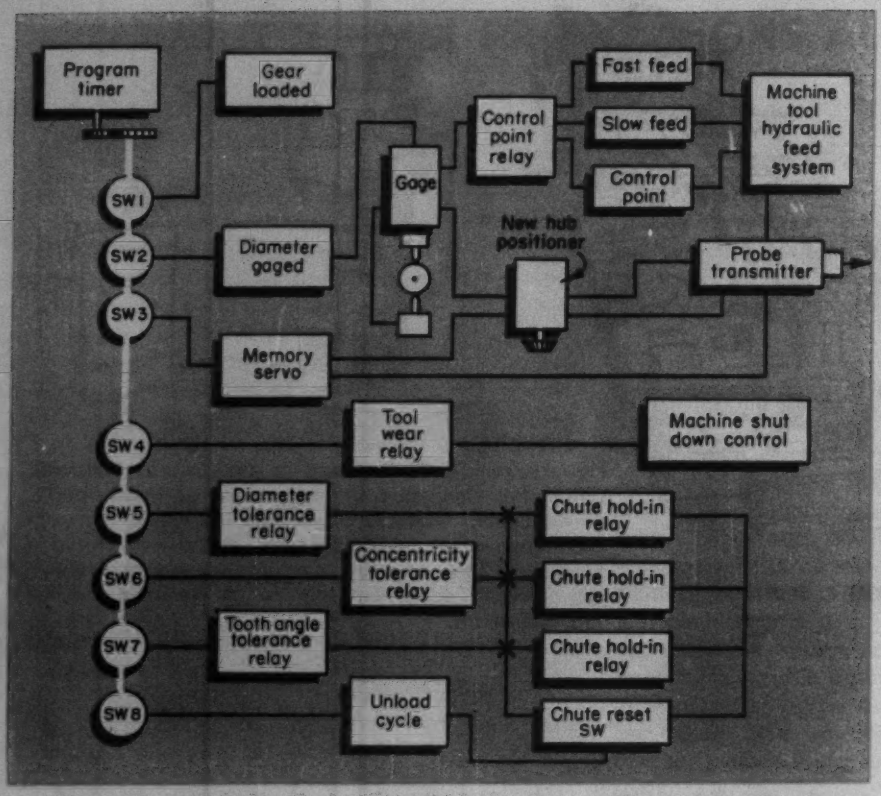

Fig. 2—Gear hobbing control system automatically checks individual gears for pitch diameter, concentricity and helix angle. Correction to machine tool can be made if three successive gears are determined to have same type of error. Machine will automatically shut down for tool change after an allowable total correction has been made.

familiar methods of business control and evaluation, let us take a look at a factory of the future. In 1955 this factory employed 200 direct labor workers, ten maintenance men, five plant engineers, and its usual indirect labor complement; in 1975 it might employ ten direct labor workers, 150 maintenance men, 100 plant engineers and the indirect staff.

What is the significant difference between the two factories? More men have been employed in more highly skilled capacities, and are undoubtedly producing at a tremendously greater rate. As to the economics of the situation . . . but wait! Are we justified in using the old familiar standards of evaluation? As we move into higher levels of production mechanization must we not also "mechanize" or more properly modernize our very standards of evaluation? Whereas, we used to calculate the cost of a product as the sum of material, labor, and burden based on a fixed percentage of direct labor cost, we now find in this future economy, that the direct labor cost has shrunk to almost nothing. Our burden has become many thousand per cent of this direct labor, so as to become meaningless by the old standards.

▶ New Standards Needed

We must now begin to think of burden not so much as indirect cost but as a very real direct cost. Perhaps we can distribute burden as a per cent of material cost, or possibly absorb it by production directly, whereby the total monthly burden for that product is divided by the past, present, or predicted number of units produced per month and added directly to the material cost of the product. At any rate, we need no longer attempt to keep our burden within bounds as a percentage of direct labor cost, but must try to hold it as a per cent of material cost, or as an absolute figure per unit product produced, or perhaps both.

Yesterday burden rates were 50 to 100 per cent. Now they are 200 to 300 per cent. Tomorrow they may be 2000 to 3000 per cent. This is good, not bad—this means higher skills, fewer working hours, higher standards of living for our society—this is progress!

By the same token we must change our thinking in evaluating the soundness of capital investment. The actual life of a machine may be of no consequence in determining its investment value. In this age of automation the rate of obsolescence of products is tremendous. Today's product is superseded tomorrow by a new and better design or a totally different product to satisfy the same need. While today's product reigns, it reigns supreme and we produce it in tremendous quantity. Machines which are automatically producing today's product are frequently designed around the special characteristics of the product and, as such, are themselves obsoleted in whole or part when the product itself is obsoleted. Therefore, in the 1975 economy we will be more interested in knowing how many units this machine will be expected to produce in the market life of the product, and we may well charge the product directly with this

fraction of the machine cost.

The purpose of this comparison is to more clearly focus the ultimate problem, in order that we may be aware of the current trend and stretch our thinking to accommodate the necessary changes in lesser degree, which we will be called upon to make in the immediate future. It is obvious that preparation for the future will include revision of the traditional standards of capital cost, amortization time, savings, etc. which guide the manager of today in establishing capital equipment policies.

Immediate Future

Let us turn our attention to the problem of the small company in the immediate future. If we read our current business journals and publications, we are accosted on every hand with the thesis that this is a current high point of a protracted boom. Profits are at an all time high, production, sales and inventories are still climbing, yet I have heard many small businessmen comment that they have never felt the pinch of competition and fight for maintaining modest profits quite so much as today. In other words, "I read about this high profit, chicken in every pot, economy, but I don't see it in my books." Without being backed by the barrage of statistics that are standard equipment before one is supposed to open his mouth these days, I might speculate that business indexes reflect very heavily the influence of the titans of American industry. It is becoming increasingly true with each succeeding merger that a relatively few American companies are the predominant factors affecting business statistics. It is, therefore, possible that Joe Doaks, manager of the small company, might truly reflect the situation in a preponderance of U.S. companies—but the gigantic strides made by the titans of sales, production and profits are sufficient to swamp the reported statistics. Fuel for this argument is added by a review of the Bureau of Labor statistics through July 1955 (which do not show the recent general trend in price increases). According to these figures, wages for all manufacturing rose from 117 per cent of 1949 wages in 1950 to 140 per cent in 1955 while prices of manufactured goods went from 117 per cent in 1950 to 114 per cent in 1955. The only way to show increased profits in such a picture is by greatly increased volume and/or outstanding efficiency improvements. The giant industries in this period have been ploughing huge sums into modern plants and modern machinery, representing an increase in the level of automation which is signaling leadership in their fields. Whereas the small company faced with slimmer profit margins may not have the volume of business or the capital required to justify the purchase of specialized and costly equipment, *Fig.* 1. This then can become a vicious cycle whereby each succeeding year makes the spread in efficiency greater between the small and the large company.

Is there no solution to this cycle? Is there no form of automation for the small manufacturer, for the special or short run manufacturer? I believe there is an answer but it involves a reversal of some of our fundamental thinking regarding automation. It is obvious upon reflection that there are varying degrees of automation or mechanization from plant to plant, from product to product, and from process to process. Recent writings have described several classification schemes which have been designed to evaluate the degree or level of mechanization. The lowest level is generally represented by work performed entirely by hand; the highest level is typified by a machine which is capable of anticipating the performance required of it and making any necessary adjustments to itself in performing the operation without error.

Self-Correction Is Expensive

At the levels representing automation, the main distinction between processes revolves around the methods of sensing and control. For example, it is possible to distinguish between processes in which a machine automatically inspects, segregates and rejects parts being produced—and a process in which a machine accomplishes the same task with the important difference that it can also correct itself so as not to make similar mistakes on succeeding parts.

By way of illustration from our own company experience, we have recently developed and are producing for a prominent manufacturer of gear

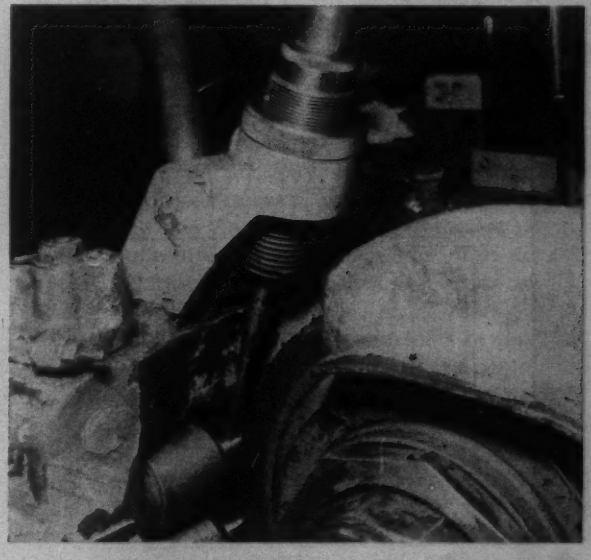

Fig. 3—In control system added to existing grinding equipment, probe is used to sense amount of stock removed from workpiece and control automatic feed means. After predetermined amount of stock is removed, feed is stopped a few microns above established dimension and a timed dress-up follows. Tolerance of finished work is in 3 to 5 micron range.

hobbing machines an inspection and control system which performs the following functions: As gears come out of the hobbing machine they are chucked automatically and gages are brought in to check pitch diameter, concentricity, and helix angle, *Fig.* 2. This information is electronically relayed to control gates which either pass the piece as acceptable or reject it into the various over or under size chutes.

A further refinement is possible. Let us assume now that three gears in a row come through oversize in pitch diameter (or on any other statistical basis desired); this information is relayed back to the servo controlled feeding head and a correction is made on the next gear to be machined to bring the pitch diameter back down to size. Such correction continues on all the machining elements being controlled until some predetermined total correction has been made (representing maximum allowable tool wear), and then the machine is automatically shut down. Automatic control in this example is a *post process* control. Actually a higher level of automation is possible—*in process* control. Again drawing on our company's experience, in another inspection and control system we are controlling the grinding of spherical rollers for bearings, *Fig.* 3. As the surface of the roller is being ground the diameter is continuously being measured. When the diameter reaches the desired dimension, the information is relayed from the gaging pickup through electronic relays to the feeding head servo and grinding is stopped, the wheel is retracted, and a finished roller is produced—held to a tolerance of ± 5 microns.

Automatic control of the machine tool represents a considerable improvement over manual adjustment—but the important point is that automatic inspection and classification represent an equally significant improvement over nonautomatic means.

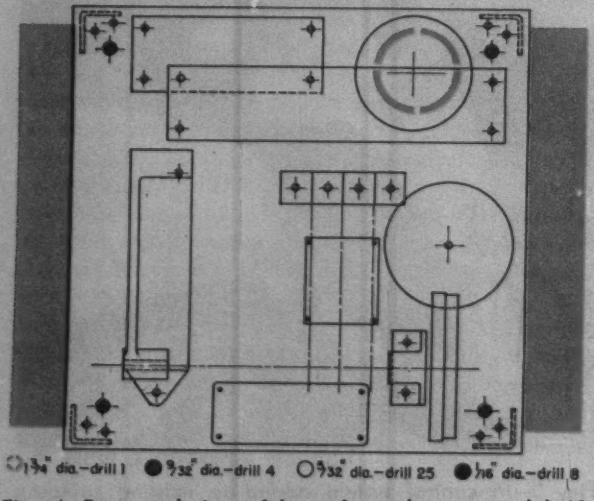

Fig. 4—Present design of base for only one model of a line of cam timers points out the use one company would have for a standardized automated drill press. Similar requirements by many smaller companies would provide a sizable market for a versatile automated machine tool.

The small company frequently rejects automation because of the high cost of automated machinery and their limited or short run production requirements. The situation should be examined carefully. The high cost of automated machinery is usually, although not necessarily, a result of introducing the control element into the design. But remember there are various levels of mechanization! It is possible to introduce inexpensive, intermediate levels of automation, which can result in great cost savings on limited run production. For example, automatic gaging devices can be easily installed on conventional machine tools; the devices will enable an operator to machine down to a predetermined line on the gage while the work is in process, and eliminate the start and stop of the machine for hand gaging.

Very frequently close tolerances are held on parts being manufactured in order that mating assemblies will function properly. It is common knowledge that the cost of a part is an inverse exponential function of the tolerances on the part and yet it may be economic to hold these close tolerances since hand sorting and matching of parts is usually an even more costly process. Intermediate automation offers us a new opportunity to review this concept. It is frequently true that automatic sorting devices, which will allow selective fits of parts machined to a much more liberal tolerance, convert what used to be a more costly method of manufacture into a new and desirable approach. There are many levels of automation and there is one that has meaning and value for every manufacturer whether he be mass producing standard products or manufacturing on a short run job shop basis. The point to keep in mind is that automation is a relative word having to do with varying levels of mechanization. The best interest of the company will usually be served by selecting the highest level of mechanization economically possible.

▶ Standard Machines Needed

Adoption of this basic approach to automation will sooner or later bring the small company face to face with another problem. Today, machinery manufacturers are making highly specialized, one-of-a-kind automation equipment for the manufacturer of highly standardized, many-of-a-kind devices. But the short run manufacturer needs the exact opposite. He needs highly standardized, low cost automated machines for the limited manufacture of specialized devices. As an example of this from our own company's experience, we manufacture a line of cam timers. The base plates for these timers come in a range of sizes and there are almost an infinite number of hole combinations that might be required to assemble all of the timers obtainable, *Fig.* 4. It is therefore necessary for us to make hundreds of layouts of these base plates and drill them. If there were available a line of standard drill presses at

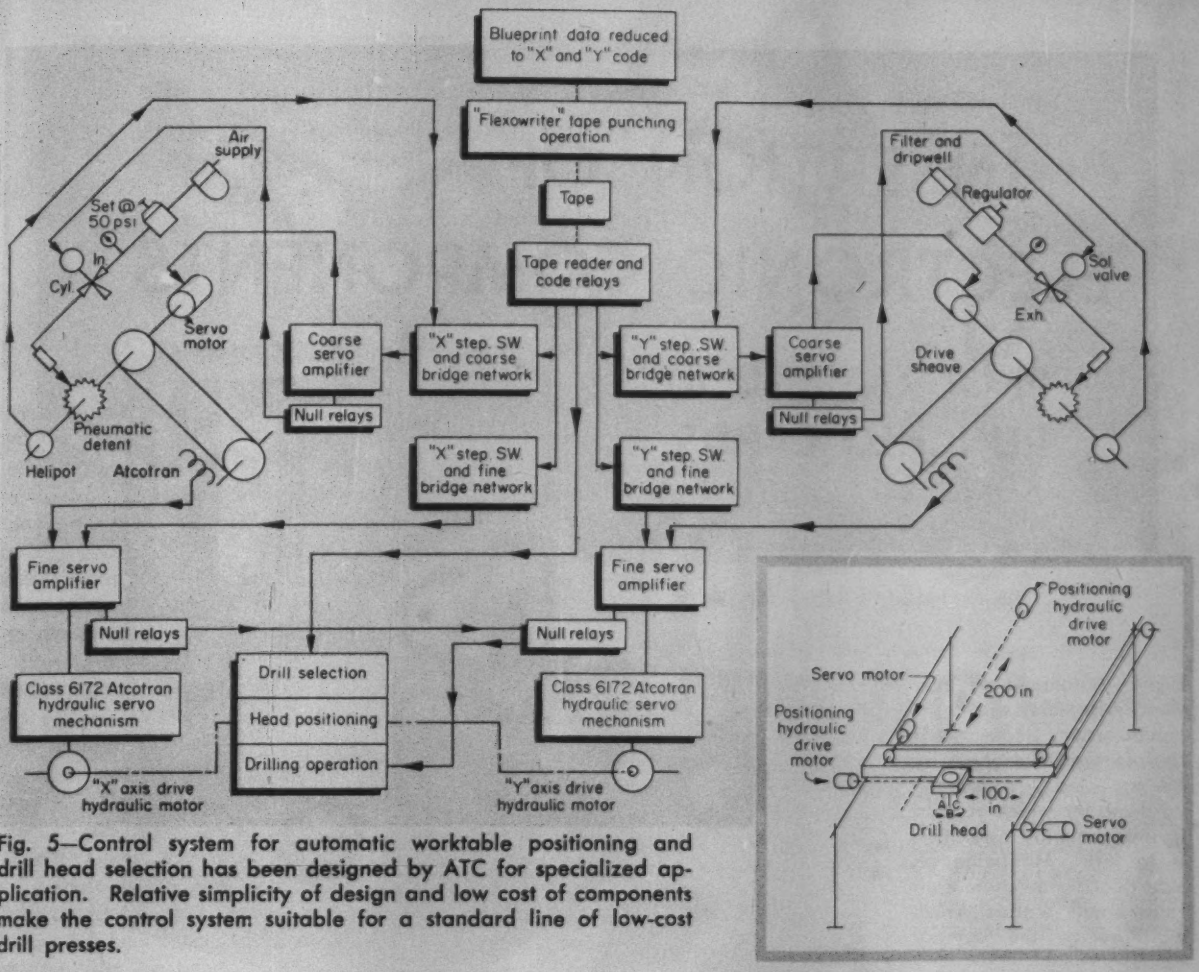

Fig. 5—Control system for automatic worktable positioning and drill head selection has been designed by ATC for specialized application. Relative simplicity of design and low cost of components make the control system suitable for a standard line of low-cost drill presses.

a reasonable capital cost which would do this job by simply clamping the base plate to the table, inserting a punched card and pushing the start button, we could save as much as $8000 per year. The saving would start in engineering where, instead of doing an elaborate drawing of the plate showing hole size and location, they might simply punch a master card and sufficient production copies which contain the *X* and *Y* co-ordinate information and hole size for each hole. Instead of making a laborious layout on the plate and hand drilling it, the plate could be clamped to the drill press table against the *X* and *Y* guides, and the card fed into the machine. The operator would push the start button and the drilling proceed until finished with precision and accuracy to within a thousandth of an inch.

▶ Economically Feasible

This is not a technical pipe dream, but a very real possibility. Our company is currently designing and manufacturing just such a control system for a very large and specialized drilling machine, *Fig.* 5. Even in this one-of-a-kind, specialized piece of automation the cost of the positioning control, from digital readout to servos and hydraulic positioners is a relatively small part of the final machine; and the basic machine involves mechanical principles and designs which are long established and proved. Such a machine, if designed into a line of standardized automated drill presses, could probably be offered at a price well within the reach of every company. Our company would be first in line to buy one because like other small companies we find ourselves in the particularly annoying position that we are manufacturers of controls for automation and yet we are unable to use automation in our own manufacture since so little has been done in developing automated machines for short or specialized runs.

The small and specialized companies in the U. S. constitute a tremendous market. If we could have versatile automatic tools and machines made available to us we could begin to cut into the great labor cost differential that separates us from the large standard manufacturer and make our lower burden rates once again felt in a good competitive economy. We should be making our voices heard today in a demand for flexible and low cost automated machines that will solve our problems. But above all, as small companies desirous of maintaining our position in tomorrow's economy, we must be attuned to the changing scene and ready and willing to utilize new techniques and equipment that *are* made available to us.

INSERTION OF ELECTRONIC COMPONENTS

PROGRAMMED BY PUNCHED CARDS

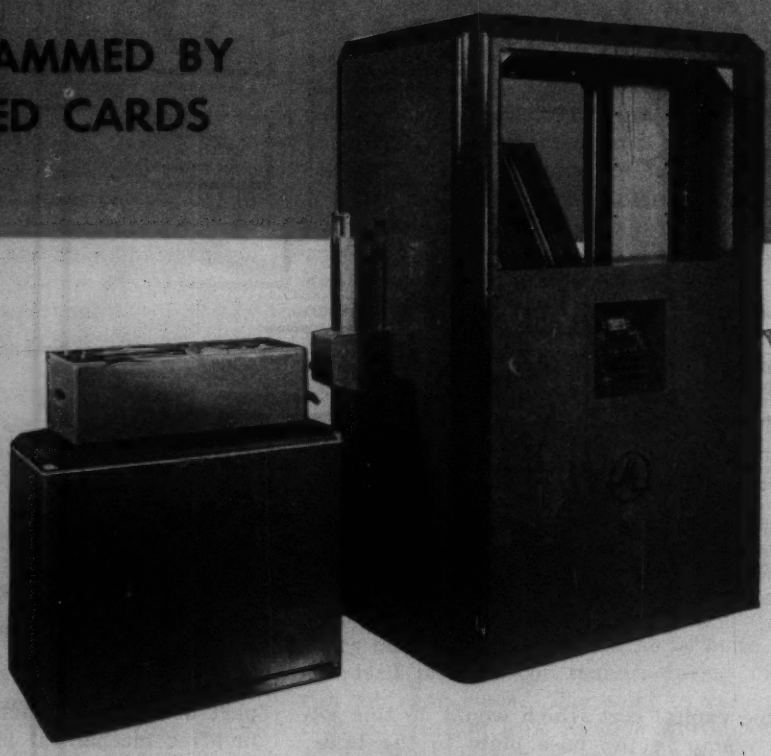

Fig. 1—Automatic machine which assembles electronic components into small boards was designed by Melpar Inc. Automatic card-reader which is used in programming operation is to left. Magazine on side of main machine contains small wafers which will receive the components.

By A. A. LAWSON
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A COMBINATION of factors such as the proved value of electronic equipment to the Armed Forces and the necessity of a strong potential production base for vital military equipment has led interested branches of the national government to underwrite projects concerned with automatic assembly of electronic equipment. Such is the beginning of Mini-Mech, an automatic assembly system designed by Melpar Inc. under a study and development contract with the Navy's Bureau of Ships.

In the Melpar design, system complexity and floor space requirements are minimized, and a high degree of flexibility has been incorporated, permitting the basic machine to be adapted for handling a variety of component parts, *Fig.* 1. Flexibility is such that the individual machines can be integrated to form a complete system or they can be used individually for assembly where production requirements do not warrant a complete system.

General Description

Automation in the Mini-Mech component assembly unit is accomplished by punch card programming, servos, and interlocking devices. Briefly in one performance cycle, an individual assembly unit will: (1) Select one component from one of six different types and transport it to the insertion station; (2) transport a wafer to the insertion station and position it to receive the first component; (3) form the component leads by bending them to coincide with holes in wafer; (4) insert the component leads through the wafer; (5) mechanically fasten the component to the wafer by stapling the leads; (6) electrically connect the component to the printed circuit by soldering the leads; (7) position the wafer to receive subsequent components; and (8) eject the assembled wafer.

In developing the Melpar system, standardization has been an efficient and economical tool, rather than a design limitation. The particular subas-

Importance of equipment which automatically assembles electronic components transcends normal commercial bounds—as evidence, consider the numerous development projects sponsored by the military. Industry benefits, however, because for this type of automated equipment the basic goals are the same for both military and nonmilitary uses—increased production and quality at lower costs.

sembly produced lends itself readily to standardization (as to size, hole spacing, etc.) since it is unitized; i.e., it consists of a general form which performs a basic function common to many different electronic circuit designs; hence, the standardized subassembly with minor modifications is widely adaptable. When necessary, the wafer subassemblies can incorporate up to four wafers with the decks disjointable for component replacement.

The axial type of conventional components were chosen for application in this system since they met general automation requirements and are available in numerous electrical values, in many physical sizes and shapes, and from many sources of supply. Components comparable in size to the average one-watt resistor fall into what can be classified, on the basis of lead bend distance, as a 0.9-inch group, and those comparable in size to the average two-watt resistor, into a 1.2-inch group. When it becomes necessary, other standardized groups will be used. They will be standardized on multiples of 0.3-inch; thus, future components might have standard bend distances of 0.3-inch. 0.6-inch, and 1.5 inches. As shown in *Fig.* 2, there are 14 discrete positions for the 0.9-inch components and seven discrete positions for the 1.2-inch components of the illustrated wafer (1.6 x 2.1 inches in size).

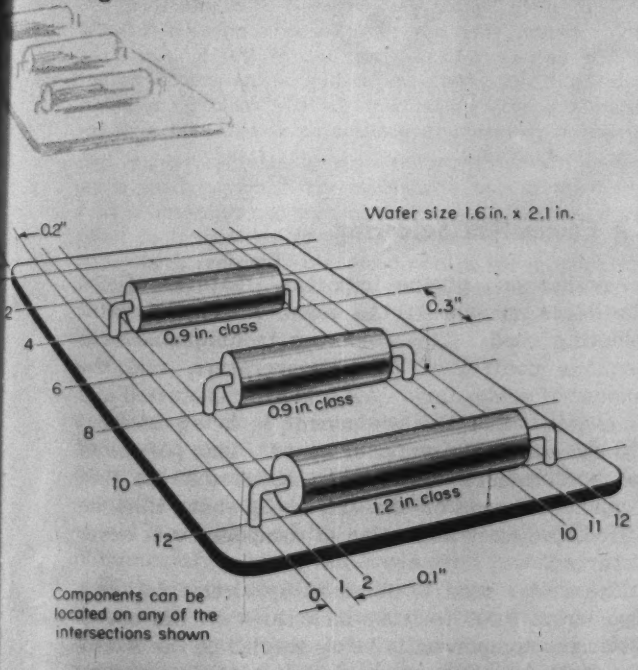

Fig. 2—Machine can assemble components with lead bend distance that varies in multiples of 0.3 inch for indicated range of sizes. Each wafer can take up to seven components in accordance with instructions which have been punched into cards.

▶ Punched Card Programming

The automatic card reader, shown on the left side of the machine, *Fig.* 1, consists of an electric typewriter stripped of all parts nonessential to spacing, carriage-shift, and carriage return functions. The space and carriage-shift mechanisms are linked together, and a means of carrying a punched card has been provided. The card, measuring 3¼ by 7½ inches has seven spaces for holes widthwise and 60 spaces for holes lengthwise.

The card reader is equipped with seven readout sensing pins. One of these is used to recycle the carriage carrying the program card; i.e., to initiate repetitive operation of the machine. The remaining six pins feed information into a binary latching relay system, which memorizes the information until the machine, upon completion of the operation, feeds back an interlock signal. When one or more wafers are punched on one card, this interlock signal causes the card to be advanced for its next readout.

In operation the punched card is mounted on the programmer and read in the following manner: A single solenoid stroke advances the card one space, then raises the carriage, causing the seven sensing contacts attached to the carriage to read one line of holes across the width of the card. The information secured from the card in this position, such as the directions to transfer the wafer and to select a component, is transmitted to the proper mechanism by means of a binary relay system. When the operations thus initiated have been completed, the programming unit receives a signal from the machine which has performed the last operation. This signal advances the card one space, thereby recycling the programmer for repetitive operation.

A single punched card, *Fig.* 3, stores sufficient information to select from one to seven predetermined components of the six different types available. The card also stores all information needed by the servos to position the components on the wafers in any one of 14 predetermined discrete locations. In addition, the card carries the information needed to transfer wafers as required and

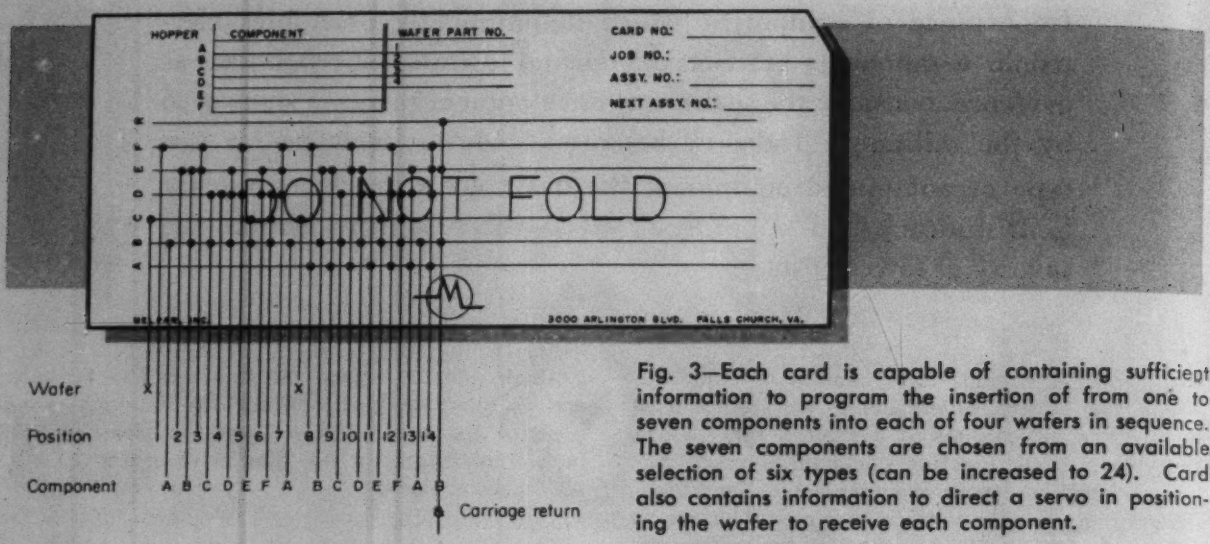

Fig. 3—Each card is capable of containing sufficient information to program the insertion of from one to seven components into each of four wafers in sequence. The seven components are chosen from an available selection of six types (can be increased to 24). Card also contains information to direct a servo in positioning the wafer to receive each component.

to assemble as many as seven components to each of four different wafers in sequence.

Board Positioning

A magazine is loaded with wafers and then inserted into a dispenser. The dispenser places the wafers on a transporting chain, which moves them to a loading station. At this station, the wafer is transferred from the chain to a retainer servo slide by means of a pneumatic servosystem. The servo locates the wafer in any one of 14 positions with respect to the contact position of the component inserting tool. When all components have been inserted, the servo returns the wafer to the loading station, where the wafer is transferred back to the chain and ejected from the machine. The operation is then repeated on a new wafer.

The pneumatic servosystem used in the locating operation is expressly designed for the purpose. Possessing excellent accelerating and decelerating characteristics, it practically eliminates hunting. The air cylinder in the motor has seven exhaust ports, *Fig.* 4. Each port corresponds to one of the seven longitudinal inserting positions of the piston. The width of the piston is slightly greater than the diameter of any of the ports, which are 0.062-inch. All ports are normally closed by solenoid-operated valves, and air pressure is applied to both sides of the piston. The piston remains inert until the exhaust port selected is opened. When this occurs, a pressure differential is created, forcing the piston in the direction of the open port until it is covered.

Exhausted air from the servomotor is sent to an air turbine wheel, which operates a rotary switch. This switch controls a piston fitted with a tapered pin in the locking cylinder. When actuated, the piston drives the pin into a tapered hole, *Fig.* 5. Thus, precise positioning ($\pm$0.001-inch) is obtained, as well as secure locking of the parts carrier of the servo. After it is locked, the parts carrier is secure enough to permit virtually any type of fabrication or assembly operation to be performed.

The new air servo has many potential design advantages:

1. Any number of ports can be built into the motor cylinder. They can be located in a straight line, staggered, or arranged in a spiral curve, depending upon the amount of center line separation.

2. Air pressure input can be brought through the center of the piston rods to a point near the piston, or it can be brought through the ends of the cylinder, depending upon whether movement of the cylinder or of the piston is desired.

3. Overall configuration of the system can be tailored to meet space restrictions. For example, the motor piston does not need to be connected directly to the carrier parts. The use of gears, racks, or levers will not affect the ability of the system to position precisely, inasmuch as the locking cylinder, by which precision in positioning is obtained, will remain unaffected.

Connection Soldering

Another one of the important features of the Mini-Mech system is the novel means of point soldering used. This soldering technique affords complete control of time, temperature, and the amount of solder flow. All soldering is started and completed while the component is being inserted and secured to the wafer or board. This portion of the performance cycle takes about 0.35 to 0.60 second. Because of the extremely short time involved, the electrical value of components is never disturbed.

The solder used is obtained by electroplating a layer from 0.006 to 0.008-inch thick on the board. While the component is being stapled to the board, the anvil, which is in contact with the component lead and is heated to 580°F, flows the solder around the lead, making a reliably soldered connection. An important part of the process is the stapling pressure exerted while the anvil is in contact with

the component lead. The pressure facilitates considerably the proper transmission of heat from the anvil to the solder.

All component leads are fastened to the board through an eyelet, which is used solely to secure the foil conductor to the board. The stapled end of the component lead is bent over the eyelet and is always soldered to the foil. Attempts to wiggle the component loose from the board have produced physical failures in the lead, but never any in the soldered connection.

Importance of Economics

For purely commercial uses, the practical application of automation of the type represented by the Mini-Mech system is obviously dependent upon the economic advantages of using it. The question of whether or not a machinery builder can meet the economic requirements, and the machinery user can afford to purchase the necessary capital equipment, can be answered only if each knows exactly how much saving is reflected in the end product.

To do this, it is important to know, and with a reasonable degree of accuracy, at what point any additional cost of the automatic equipment will be liquidated with the accrued variable cost savings. This is the point at which the accrued automation costs become equal to, or less than, those which would have accrued by using hand methods. This is commonly termed *the break-even point*.

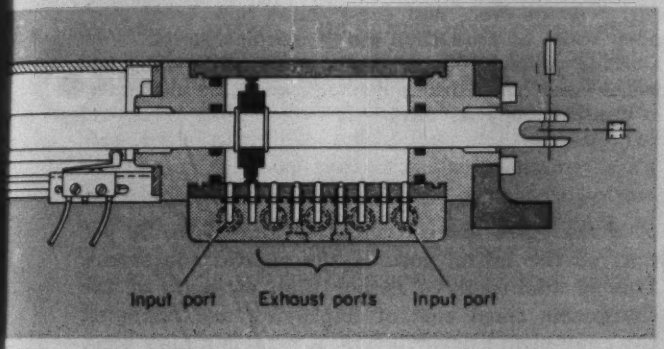

Fig. 4—Air cylinder in servomotor has seven exhaust ports, each of which corresponds to one of the longitudinal inserting positions of the piston. Pressure is applied to both sides of piston; when signal from programmer is received, solenoid-operated valve opens particular port and piston moves until port is covered at which time the pressure on either side of piston is balanced.

It is also important to know whether the automatic equipment can adapt itself economically to a level of production lower than that produced in a regular 8-hour day, and by exactly how much. This information can be obtained by means of what is termed a *break-even load curve*.

On the basis of these criteria, an attempt will be made to show how the Mini-Mech compares economically with hand methods of assembly. In making the comparison, rather conservative estimates are used of the capabilities of the Mini-Mech system. Based on conventional methods of accounting, the comparative techniques employed reflect particularly the influence of fixed and variable costs. Although a few hypothetical figures are necessarily used the accounting principles are applicable to most systems.

An important factor which first must be considered and resolved, is the "useful life" of automatic equipment. As a general rule for tax purposes this is frequently considered to be 15 years. However, the use of automatic machines in a relatively new field, such as electronics, poses a problem because of the potentially rapid changes of existing electronic components and the development of new ones. Amortization of the capital equipment must therefore be reduced to a shorter period. Accordingly, a period of three years has been allowed in the analysis for the liquidation of this initial capital expense.

Of pertinent importance to this subject, we quote a paragraph from page 1 of *Bulletin F, Internal Revenue Service Publication* 173: "Taxpayers may determine reasonable periods of useful life for their depreciable property on the basis of their particular operating conditions, experience, and informed judgment as to technological improvements and economic changes. However, the periods of estimated useful life used by taxpayers are subject to review by the Internal Revenue Service, and

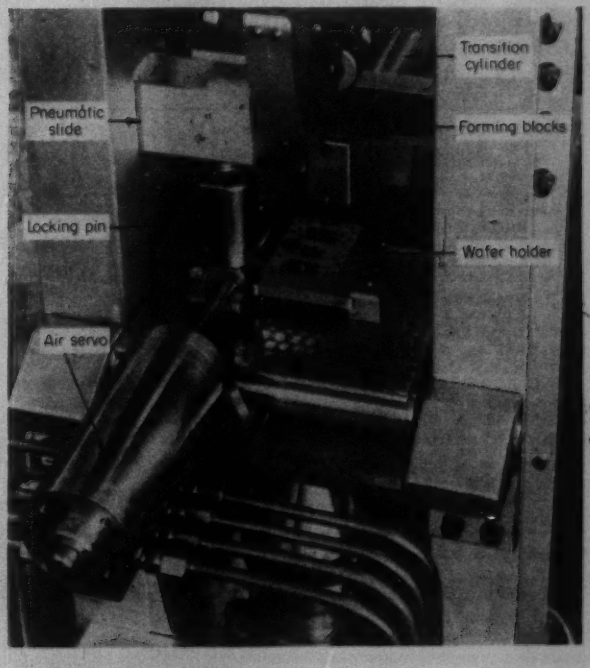

Fig. 5—Exhausted air from air servo operates rotary switch by means of small air turbine. The switch controls piston fitted with taper locking pin which, when positioned, securely locks wafer holder preparatory to complete operation consisting of insertion and soldering. Stapled ends of leads are bent over the eyelets and soldered to foil conductor on bottom of board.

taxpayers should be prepared to substantiate the periods so used."

Discussion of Costs

Tabulation of figures which compare the hand and machine assembly methods is shown in *Fig.* 6. As can be seen the three items constituting the *major* fixed costs are: (1) Capital equipment, (2) installation, and (3) modification costs. Actually the selling price of Mini-Mech has not been established. For example purposes it is estimated that the system might require an initial investment of $25,000.00 (This figure has been arbitrarily projected from announced prices of similar equipment.) The cost of corresponding hand-production equipment is estimated at 10 per cent of the automatic machine equipment since the hand equipment needed, including tools, benches, and small aiding devices is relatively simple.

Modification costs during the amortization period

COSTS	HAND	MACHINE
1. Fixed Costs		
Capital Equipment	$2500.00	$25,000.00
Installation	200.00	200.00
Modification of Equipment (50% of Capital Equipment)	1250.00	12,500.00
Totals	$3950.00	$37,700.00
Difference	$33,750.00	
2. Variable Costs (per 8-hour day)		
Material ($1.55 x 1728 wafers)	$2678.40	$2678.40
Direct Labor		
Machine Operator (1 ea. x 8 hrs. x $2.00)	.....	16.00
Assemblers (9 ea. x 8 hrs. x $1.50)	108.00	.....
Stock Handlers (1 ea. x 8 hrs. x $1.50)	12.00	.....
Group Leader (1 ea. x 8 hrs. x $3.00)	24.00	.....
Quality Controller (2 ea. x 8 hrs. x $2.00)	32.00	32.00
Overhead (100% of Direct Labor Costs)	176.00	48.00
Cost of 8 changeovers	29.63	10.87
Totals	$3060.03	$2785.27
Difference		$ 274.76
3. Break-even Point		
(Difference in fixed costs/differential in variable costs)	$33,750/$274.76=123 8-hr. days	

Fig. 6—Comparison of major costs of hand versus machine assembly. Data are based upon amortization period of three years (1095 days) for automatic machine capable of inserting 24 components per minute (approximately 10,000 per 8 hours) into wafers, each of which requires six component insertions.

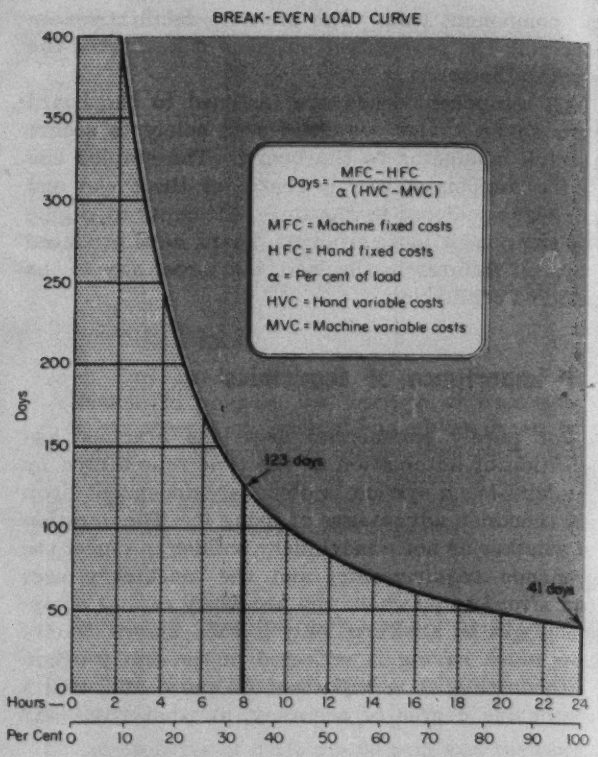
BREAK-EVEN LOAD CURVE
Days = (MFC - HFC) / α (HVC - MVC)
MFC = Machine fixed costs
HFC = Hand fixed costs
α = Per cent of load
HVC = Hand variable costs
MVC = Machine variable costs
Days
123 days
41 days
Hours — 0 2 4 6 8 10 12 14 16 18 20 22 24
Per Cent 0 10 20 30 40 50 60 70 80 90 100

Fig. 7—Break-even load curve shows how break-even point varies as production use of machine varies. With machine utilized 100 per cent of time, differential between hand and machine methods would be eliminated in approximately 41 days.

of three years are estimated to amount to 50 per cent of the initial cost of the capital equipment. This is admittedly a rather high estimate of the chargeable fixed cost of improving and changing the equipment; nevertheless, a rate this high must be anticipated in order to keep abreast of new components, which are certain to make their appearance during the life of the machine. Obviously, in order to get the most out of the new techniques of automation it becomes necessary to tailor the machine to the characteristics of the end product, especially in an expanding field such as the electronic industry. The concurrent development of machines and end products must be faced realistically as an expensive fixed cost item.

Of the variable costs, that of material (purchased components) is unquestionably the largest item. The cost of material is frequently quoted at 70 to 90 per cent of the total cost of the end product. The purpose for citing these percentage figures is to emphasize the point that only a relatively small saving is possible by the use of automatic machines.

In setting up comparable variable cost figures, the initial step is to use the machine production rate, which in the case of Mini-Mech is 24 component insertions per minute. It also becomes necessary to establish the rate at which components can be assembled by hand methods. This generally averages about two component insertions

per assembler per minute; however, to facilitate comparison (by using a round-numbered ratio of 10 to 1), a rate of 2.4 component insertions per minute is used. Thus, approximately 10,000 component insertions are possible with a machine in an 8-hour period; and to insert an equal number by hand would require nine assemblers and one group leader if current practices prevail.

It will be noted that an overhead cost of 100 per cent for both hand and machine methods has been used in the analysis. It is conventional accounting practice to express overhead in terms of per cent on direct labor costs. Automated systems, with their substantial decrease in direct labor, will unquestionably change this practice of determining overhead. Such items as dollar volume of production or fixed costs might prove more appropriate than direct labor in setting up overhead costs.

A word of explanation with regard to changeover costs becomes necessary at this point. In the analysis, an assumption has arbitrarily been made that changeover by manual production can be accomplished in 5 minutes. This is believed to be generous in view of the fact that manual changeover involves complexities which are difficult to predict or calculate.

Changeover costs are reduced and can be readily determined in programmed machines such as the Mini-Mech system. With downtime between changeovers of 5 minutes for both hand and machine methods, the cost of eight changeovers is determined by proportioning the daily fixed and variable costs over the total downtime period (40 minutes). It is believed that programming is an important factor for obtaining lowcost downtime between changeovers. This is not obtainable in systems where the individual machine heads must be accurately adjusted for positioning with respect to the printed wiring board.

▶ Break-Even Point

It is important to remember that the break-even point of 123 days is based on 10,000 component insertions per day (8 hrs.). However, if the machine is in continuous operation 100 per cent of the day, or 24 hours, the break-even point will be reduced to approximately 41 days. The load curve, *Fig.* 7, shows how the Mini-Mech system adapts itself economically to a limited reduction of production.

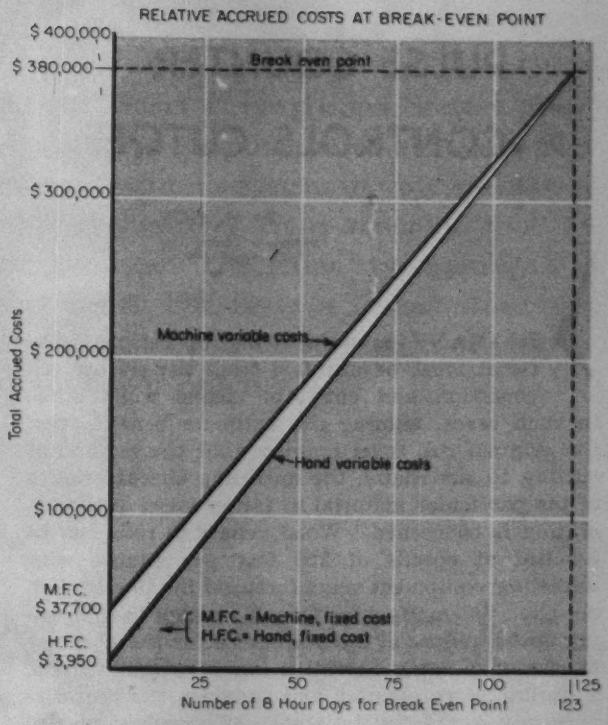

Fig. 8—Presentation of data which shows break-even point can be made by plotting accrued variable cost starting from point on graph representing fixed cost for methods being compared. Extension of plot would effectively illustrate continual savings to be expected with use of machine methods.

Another method of presenting the break-even picture is to plot the total variable costs for both hand and machine methods in relation to their fixed costs. This is done in *Fig.* 8, which shows the number of days required for the total accrued fixed costs and variable costs for automation to equal the total costs which would have accrued with hand methods.

From a study of this comparison of costs, the value of properly separating costs into two categories, fixed and variable, becomes obvious. It is also apparent that the economics study is of equal importance to both the machinery builder and the machinery user. The machinery builder should use an economics study to guide his development, keeping the capitial cost at an economic level. The machinery user should use it to determine his variable cost savings and break-even point.

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PULSE COUNTER CONTROLS CUTOFF

By M. PICK
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IN MANY manufacturing operations, material must be unrolled from the as-received condition and cut into usable work sizes. In such cases, gaining the optimum benefit from the original roll form requires that the method of cutting to size match the unreeling characteristics of the particular material so far as speed of the operation is concerned. Wood veneer in rolls can be handled at speeds of 250 feet per minute with unreeling equipment manufactured by Merritt Solem Div., Solem Machine Co. To match the unreeling speed, a special control device for the shearing to size or clipping operation has been built around a digital pulse counter and provides the requisite accuracy, speed and reliability of operation needed in cutting the veneer into pieces of desired widths. The control was developed in co-operation with the Pascagoula Veneer Co. and followed an investigation into other existing means which were felt to be inadequate.

As veneer unwinds from the reel, it moves by a conveyor belt toward the clipper and actuates an impulse exciter through a gear and measuring wheel arrangement which generates one pulse per inch of lineal movement, *Fig.* 1. The pulses of the exciter, representing inches of length, are accumulated by the control device. When a desired count is reached, the clipper knives are actuated. At constant speeds up to 200 feet per minute, repeat accuracy of ¼-inch in 100 inches has been obtained with the electronically controlled, electrically actuated clippers.

Versatility is added to the system by provisions for rapidly changing the point at which the clipper is actuated. Widths in increments of 1 inch can be selected as desired up to a possible 129 inches. To make the selection, the control panel is provided with two dials; one dial is for tens of units, the other for units, and all that is needed is to turn the dials to the width desired, *Fig.* 2. Production efficiency is further enhanced by a provision that up to six different widths may be preselected and stored by the control. During unreeling operations, selection of any one of the preselected widths is rapidly made by manipulation of simple position switches similar to those used on a telephone switchboard.

The components of the system include the impulse exciter, control panel, and electronic cabinet containing the necessary circuits and relays. As might be expected, since the control was designed in close co-operation with the user, maintenance of the electronic equipment was given serious consideration. Trouble in circuits can be isolated by a reference to a series of signal lights mounted on the control panel. Electronic circuits and components are the plug-in type and in the event of trouble can be replaced by the operator who requires no special training in electronics. At counts that do not exceed 3000 per minute, the equipment operates well within the range of 40,000 counts per minute possible with the digital counter.

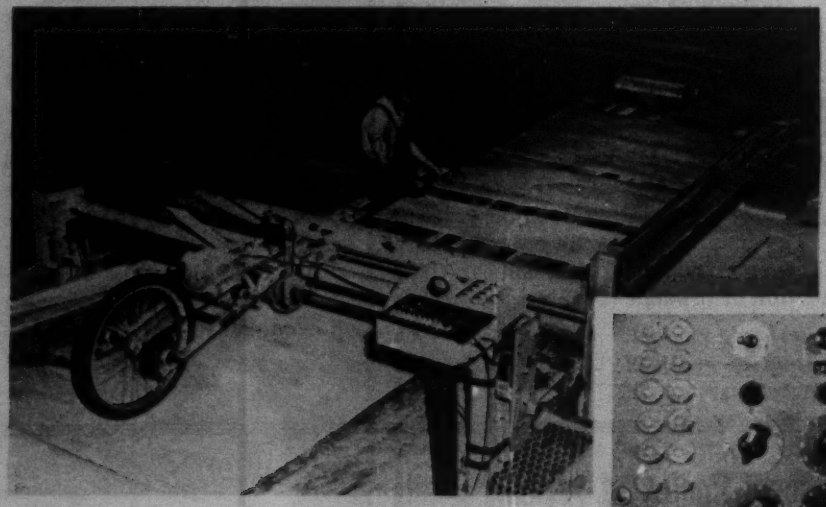


Fig. 1—Wood veneer in rolled form must be cut into usable width sizes. Automatic control of this Merritt Solem clipper in the cutting to size operation is provided by a wheel driven exciter which measures inches of length of the moving veneer strip and an impulse counter control which actuates the knife at a desired count.

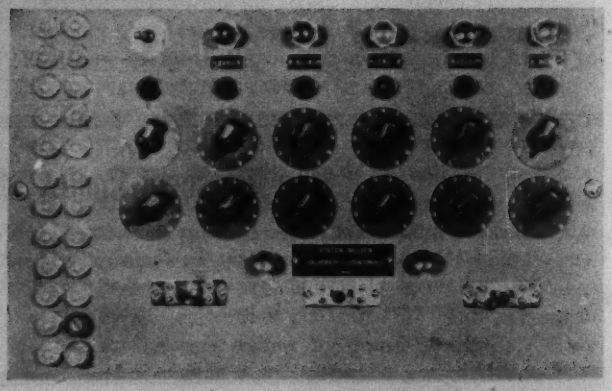
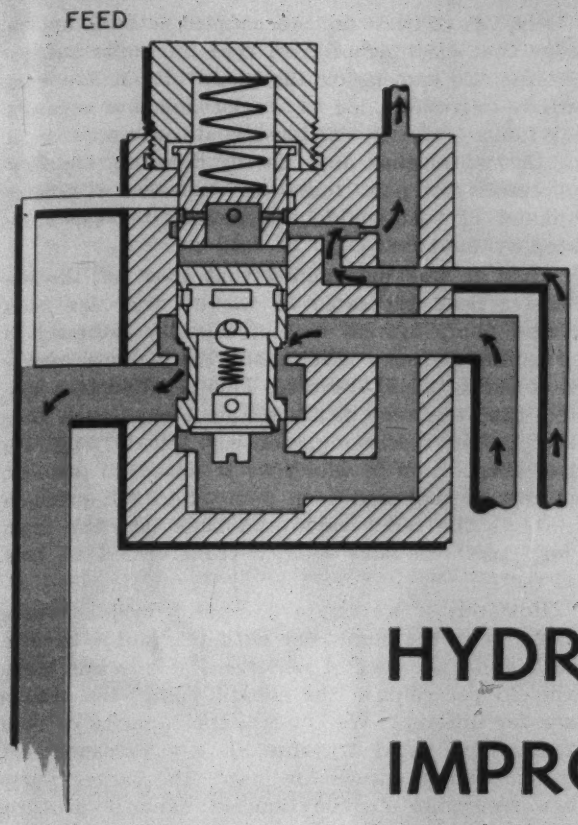


Fig. 2—Dials provide means of preselecting up to six different widths which can be stored by the sizing control. Position switches determine the preselected width which is used at any one time.



At the recent Pennsylvania State University program on automation, the author discussed hydraulic system improvements and also evaluated various machine tool arrangements. The latter was published in the August 1956 issue of *Automation;* here are his comments on correction of past hydraulic shortcomings.

HYDRAULIC SYSTEM IMPROVEMENTS

EXTEND MACHINE TOOL RELIABILITY

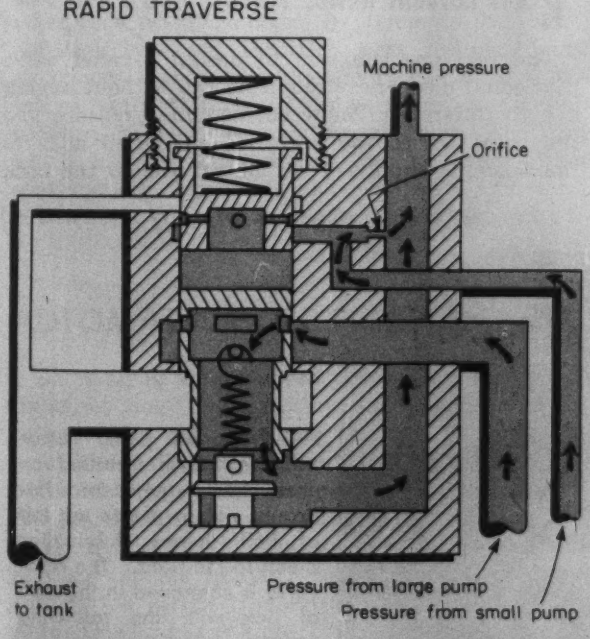


Fig. 1—Diagrams of relief valve in two positions. This valve uses an oil column on the relief valve spool to maintain constant pressure. The valve will function with about a one psi differential—that is one psi differential will cause the valve to dump the output of the large pump to exhaust, or add the output of the large pump to machine pressure. The adjustment above the upper spool is to set relief valve pressure.

By CLIFFORD G. MENARD
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WHY did machine tool builders undertake vast research programs after the close of World War II and what are some of the fundamental points learned?

To provide background to answer these questions we should examine the effects of the war on machine tools and the problems presented.

World War II had more to do with the advancement of machines than any other comparable period of time. This came about to a large extent through development of piston-type aircraft engines and the fact that they had to be made on a production basis. Why is this true even though mass production was rather common at the beginning of the war? The answer is that most parts in production were relatively small compared to aircraft parts and the tolerances which the aircraft companies required (spacing between bores, squarenesses and diameters) were much closer. Most of these parts were aluminum or magnesium, making the machine tool manufacturer's problem more

serious regarding dimensional stability, but of course easier regarding machining qualities.

Previous to the war aircraft parts were made on universal type machines in small quantities and assembly fitted by skilled mechanics. With the coming of mass production, interchangeability of parts became a necessity. This brought out weaknesses in machines such as difficulty in maintenance of alignment, height variations, machine stability, lead changes on hydraulically operated machines, and many others. Temporary solutions were used, such as temperature controlled hydraulic systems, built-in levels, addition of more leveling blocks, scraping heights after the machine was at operating temperature, and other devices which would help to produce parts uniformly and within tolerances. But this added a heavy load on machine maintenance departments to keep equipment in production 24 hours a day.

Hot Hydraulic Oil

Hydraulically operated equipment went through a drastic change and most of the principles involved are still utilized. Heat in the hydraulic oil was a large part of the problem—oil temperatures went as high as 150 degrees. Most machines of this era had the oil tank built into the base of the machine which caused distortion of the bases, warping of the ways, and concentrated loading on the ways resulting in excessive wear. Since most machines used hydraulic oil for way-lubrication, a poor condition existed between the way surfaces and the tables exclusive of distortion problems.

Analysis of these factors, coupled with the knowledge that cleaning of base type oil tanks and replacing the screens on the pump intake line were nearly impossible, led to the decision that separate oil tanks properly designed could eliminate most of these problems, and that by directing the flow of return oil past radiating surfaces, a greater amount of heat could be removed than was radiated by the base.

Then it was determined that most of the excessive heat generated in the oil was due to a single pump system with a capacity designed to maintain pressure throughout the volume expansion during rapid traverse. This resulted in a system that was very inefficient since most cycle time is spent in machining, not rapid traversing. We had a condition in which we returned 75 per cent of the oil that had been pumped to full pressure through the relief valve and back into the tank, with this excessive energy transformed to heat in the oil.

However, if we use a two-pump system whose capacity is the same, but with the pumps divided so that 75 per cent of the capacity is in one pump and 25 per cent in the second pump, the results are far different. We can use the capacity of both pumps for rapid traverse at low pressure, but when feeding speeds are used, the larger pump can recirculate to the tank at exhaust pressure while the smaller pump maintains machine pressure. These conditions allow use of a lower horsepower motor and result in much less heat in the oil.

Oil Column Relief Valve

The real problem was to design a relief valve that could meet these requirements without having a high differential between machine pressure and the point where the high volume pump adds to the machine supply of oil, or returns to the tank

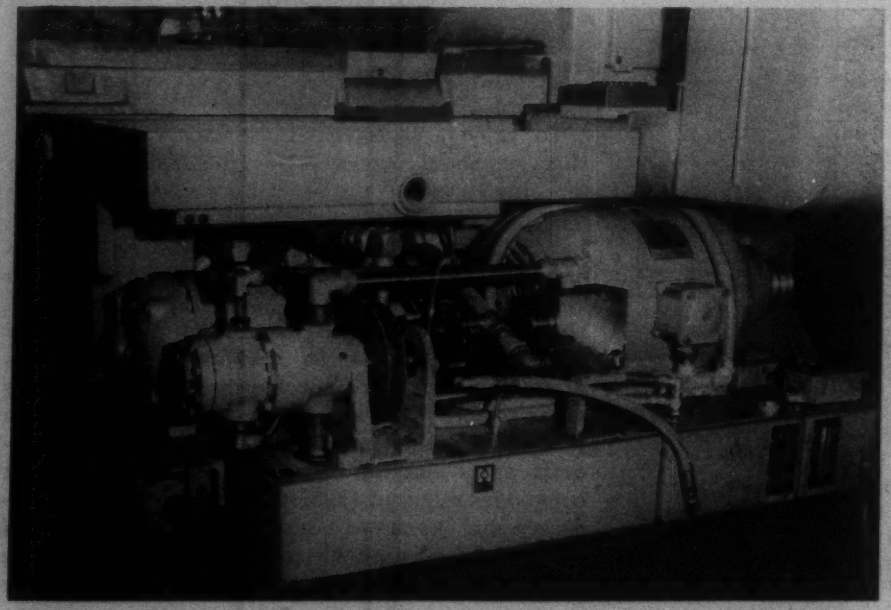

Fig. 2—Double pump system with belt drive installed on production equipment. Hydraulic pumps are to the left of belt sheave, lubrication pump to the right. The relief valve is contained in the metal box with the reflecting surface.

at exhaust pressure. An interesting valve with this characteristic is one that uses a hydraulic oil column as the medium for maintaining machine pressure. Regardless of the height of the oil column due to the position of the relief valve spool, constant pressure can be maintained. Of course this is not the case when a spring is used on the relief valve spool to maintain pressure.

This valve can best be described by examining *Fig.* 1. The constant pressure oil column is between the two valve spools. The function of the upper spool is to maintain the pressure of this oil column. This spool is floating between a pressure band and an exhaust band, maintaining the pressure of the column of oil. The lower spool is the relief valve spool and is hollow in construction with a clapper type seat on one end. When the pressure builds up on this end of the spool the clapper valve closes and relief valve spool moves up into its relief position and opens the large pump to exhaust. If the machine pressure falls, the relief valve spool moves down, closing off the oil from the large pump to exhaust. Now the large pump will start to pump through the center of the relief spool, opening the clapper valve and furnishing more oil to the machine.

▶ Other System Refinements

To eliminate changes in feed rates of hydraulically operated machine tables caused by viscosity changes in the oil, the machine tool builders performed experiments to determine how hydraulic oil could be throttled but not change flow characteristics with changes in temperature. Many different types of throttles were designed such as bimetal types which changed the size of the orifice with changes in temperature, a constant pressure-drop orifice and many others. The type which has worked out best can be made either continuously adjustable between zero and some maximum feed rate, or made so that several different fixed feed rates are available for use. This type of throttle usually maintains feed rates within 5 per cent of set point without the use of any outside controls and is therefore trouble free. This refinement alone advanced hydraulic systems and their use in machine tools to a high degree of performance; in fact, in most factories these throttles can be locked while the machine is in production.

Some other refinements that were built into machine tools were improvements in the mounting of hydraulic cylinders. Now they are usually flange mounted from one end so that expansion of the cylinder does not distort the base. Whenever foot mounted cylinders are used they are generally designed with an expansion joint to compensate for heat differentials between the base and cylinder.

On pump drives the design is changed somewhat. Instead of in-line drives which were once universally used, many manufacturers are now using belt driven pumps. This does not mean in-line drives were inadequate, but the problem of aligning a motor manufactured by one company and a pump manufactured by another almost invariably led to shims under either the pump or the motor.

With a belt driven pump the alignment prob'em disappears and a feasible method for separate way-lubrication is provided. The machine pump bracket can be used to mount both the machine pump and the way pump. Both can then be driven by the same belt which interlocks the pumps so that any time the machine pump drive is started, the machine automatically has way-lubrication, *Fig.* 2. The bracket is U-shaped—fabrication is relatively simple and alignment is assured.

These improvements in hydraulic systems have contributed in large degree to the vast growth and increased efficiency of product in the machine tool industry as evidenced by the popularity of hydraulics. Developments are continuing so that customers can expect better and better performance from automated equipment purchased.

AUTOMATIC HOLE FINISHING

Ballizing is a high-speed process for sizing and finishing holes by pressing an oversize ball of suitable size and hardness through an undersize hole. The balls are self-centering in the hole, do not need to be guided, and cannot produce an oversize hole. Through the use of recirculating fixtures and sufficient tungsten carbide balls, this process can be adapted to high-production and automation setups. Industrial Tectonics Inc., Ann Arbor, Mich., has engineered such automatic equipment. The specially designed machines include a vibrator hopper for parts feed, suitable parts fixtures, electronic controls, and ball circulating means.

Ballizing has been used successfully for holes ranging from 0.030 inches to 5 inches in diameter, with hole diameters between 1/16 and 1 inch giving optimum results. Generally, the hole length should not be more than 10 times or less than 1/20 of the hole diameter.

The balls are usually 0.0005 to 0.002 inches larger per inch of diameter than the high limit of the hole before ballizing. This interference fit causes the ball to exert a radial force on the hole wall. Normally, this force is insufficient to cause an objectionable change in the overall size of the work; yet the unit pressure is very high, for the force is concentrated on a narrow line of contact between the ball and the hole wall.

Unlike other hole finishing processes, ballizing does not remove metal; instead, it operates by a burnishing action which compresses and smoothens the surface by cold working a thin layer of the hole wall material.

AUTOMATIC TEMPERATURE CONTROL

Though primarily a broad survey of some of the more pertinent points of automatic temperature control, this article can be considered as a review of instrument controls in general. The means of accomplishing automatic control of temperature are based on principles readily applicable to the control of any process variable which can be measured and expressed in terms of electrical equivalents.

By R. K. WEST
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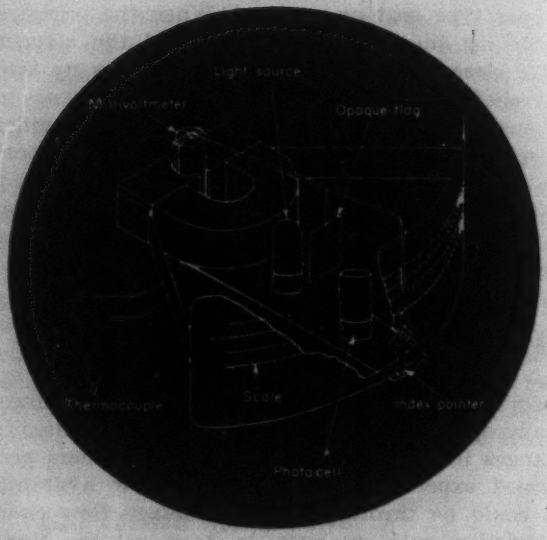
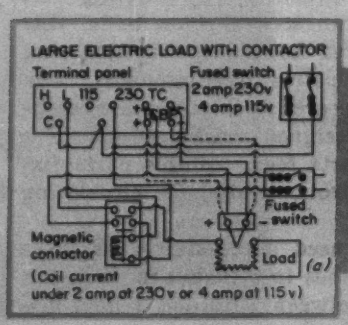


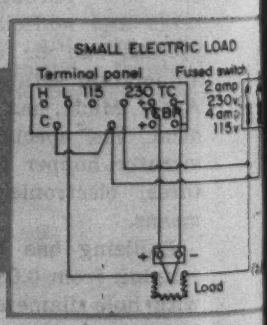
TEMPERATURE CONTROL in industry began with experienced operators who were able to look at, touch, smell or even listen to a process and judge with surprisingly reasonable accuracy that the temperature was proper for their processing needs. Though it sufficed for its time, the subjective approach to temperature control has been supplanted by the evolution of technolgy. Even if desirable, two major factors exist which would make the completely manual procedure obsolete: (1) Skilled operators have been replaced by a generation of labor that has not had equivalent apprenticeship training and, (2) the requirements of modern industry can only be met by routinely exercising control accuracies beyond the sensing ability of the best of operators.

Historically, temperature controls have passed through several intermediate stages of development: The operator's guess gave way to measuring means; indicating instruments were devised which would give the operator more accurate information upon which to base his decision to vary power input in obtaining the desired results; and eventually, automatic temperature control systems evolved as we know them today. Automatic controls were created for problems which needed to be solved if overall industrial progress were to continue. With manual control based on reference to instrumentation, rejects resulted due to the operator not giving his full attention to the process at a critical time. Further, many industrial processes required accuracies beyond the capability of the best trained operator giving his full attention to the problem. The modern instrument may effect proper control action before the indicated condition would become apparent to the manual operator.

Today, economic considerations will normally dictate the use of automatic control equipment, over and above the foregoing reasons, since instruments can automatically control the process to extreme accuracy without the hourly expense of an operator's attention, and at an initial cost approximating perhaps two weeks of an operator's wages.

Within the field of automatic temperature control, technical evolution has continued. It has been determined that simply controlling a furnace, oven or machine component to a given temperature has not answered all problems in every instance. Standard *On-Off* temperature control instruments have been modified to more automat-





. . . . A BASIC AUTOMATION TECHNIQUE

Fig. 1 (Left)—Sketch of an indicating and controller pyrometric instrument manufactured by West Instrument Corp. In response to the sensing of the thermocouple, the index pointer carrying the opaque flag moves. A relay circuit is controlled by the photocell and light arrangement attached to another arm which can be set at any desired temperature. Interruption of the light source by the opaque flag actuates the control relay.

ically regulate industrial equipment under a variety of special conditions and, gradually, the most common of the one-time special instruments have become standard configurations. A complete understanding of the scope of the various modern control modes is important to the man in industry who is interested in automatic operations and obtaining the maximum utilization of instrumentation.

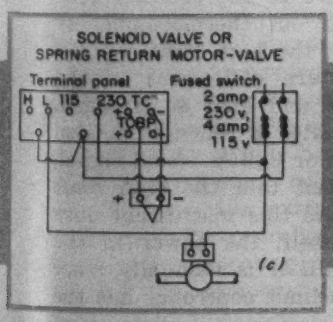
▶ Basic Instruments

On-Off control instruments are the basic instruments of automatic temperature control. As modern temperature measurement primarily deals in quantitative electrical effects associated with temperature changes, a majority of the instruments are built around electrical and electronic components and circuitry. The fundamental problem is one of measuring changes in voltage, and either millivoltmeters or potentiometers are generally incorporated in such an instrument.

A good example of the general principles employed is afforded by the West pyrometric control which utilizes the deflection of the pointer of a millivoltmeter to achieve operational control. As an example, consider a problem in maintaining a desired furnace temperature. A thermocouple placed in the furnace or at any other point where control is desired, will generate a minute electrical current whose voltage varies in proportion to changes in temperature to which the thermocouple is exposed. The current causes the deflection of the millivoltmeter pointer which swings across a scale calibrated for temperature, *Fig.* 1. A manually operated setting arm on the instrument determines the desired temperature. This setting arm is provided with a small light source which is projected upon a photocell which in turn, controls a relay circuit. When the actual temperature sensed by the deflecting pointer reaches the desired control point, an opaque flag carried on the pointer arm interrupts the light beam and actuates the relay system, shutting off power input. As the furnace temperature is reduced, the pointer drops below the control point, the flag is no longer interposed between light source and photocell and the relay system turns on the fuel or power supply to bring the furnace up to the desired temperature.

Relay action permits using these fundamental instruments in a variety of ways in addition to the conventional *On-Off* control of electric power. In addition to the wiring possibilities shown in *Fig.* 2, many control problems relating to electrical loads have been solved by using a *High-Low* control of the electrical load. In some cases this has been done to provide accurate control of heaters having a small thermal mass by using a manually adjusted Variac or Powerstat on the low load and selecting a heater of such capacity as to provide only slightly more heat than would be required for the process under normal running conditions. The instrument is then wired into the circuit as in *Fig.* 2(d). The heating and cooling cycle must of necessity be less severe, heater life is extended due to reduced thermal shock and the net result is improved temperature control which can be partially regulated manually as far as the cooling rate is concerned.

The same end result may also be obtained on three-phase power heating applications by utilizing a three-pole double-throw contactor wired to switch from Δ to *Y*, again eliminating the need for excessive wattage input on the heating cycle since



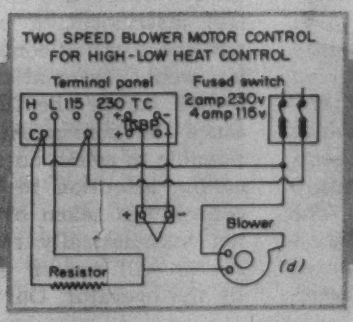


Fig. 2—Examples of circuits which are used in controlling the temperature in various applications. The terminal panel is represented as found in a West controller chassis. The relay circuit would be through contacts marked *H*, *C* and *L*.

the low heat portion of the cycle is also contributing to the total heat input. With this technique, power input to a heater will be modulated between full power in the Δ condition and one-third power when connected in *Y*, *Fig.* 3. Again, heater life is extended and improved control is obtained with a possible reduction in heater wattage, which results in a lower demand rate.

Further Refinements

Proportioning or anticipating controllers offer the same switching possibilities as *On-Off* controllers with the added advantage that they will give more precise control. This result is accomplished with different means by the various manufacturers of pyrometers; but essentially, all proportioning pyrometers anticipate the control action required by changing the relay position from heating to cooling, for example, before the actual temperature is up to the desired running temperature. The same anticipating action is automatically introduced whenever the true temperature approaches the point where heat should again be provided. The term proportioning is applied since the instruments proportion the amount of *On* and *Off* time of the heater while they are within a control band and do so depending on the difference between desired and actual temperature and whether the actual temperature is above or below the desired temperature. The sequence of control as a heater comes up to temperature would be as follows: Full power, 70 per cent time *On* 30 per cent time *Off*, 60 per cent *On* 40 per cent *Off*, *On* time equal to *Off* time, 40 per cent *On* 60 per cent *Off*, 30 per cent *On* and 70 per cent *Off*, and it might then cycle 20 per cent time *On* and 80 per cent *Off*. As the indicated temperature passes out of the proportioning control band the heat would remain *Off*. These time cycles are given to show how the power is proportioned with respect to the relative positions of the instrument temperature indicating pointer and the control index. The values given are only arbitrary, but for a typical instrument it would be possible to reproduce the above ratios to demonstrate this relationship.

Due to the above proportioning or anticipating action, the thermal inertia of the heater is reduced as it comes up to temperature and also as it cools since the instrument has introduced rate action or a different amount of heat depending upon the temperature offset from the desired temperature. This results in a tendency to stabilize the temperature since the rate of cooling or heating is further reduced each time the temperature moves within the proportioning control band. The resultant control action is illustrated in *Fig.* 4 in which proportioning control action is compared with an *On-Off* controller action for a given heater.

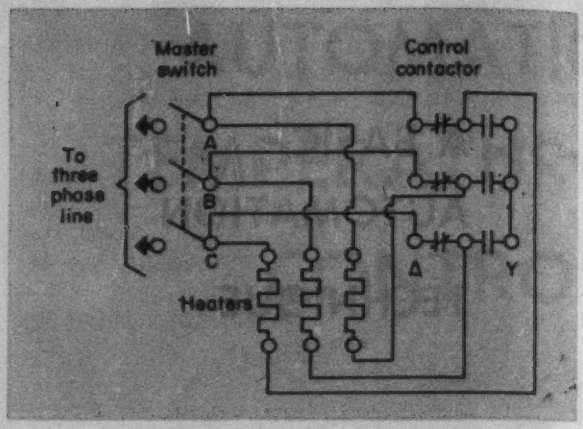


Fig. 3—In three-phase heating applications, the ability to switch the heating elements from Y to Δ connection provides for simple modulation of power input.

The use of proportioning control has become standard in several industries. For example, in view of the general requirement for improved temperature control in processing plastics, either in injection molding machines or extruders, proportioning control instruments have been almost universally used in that industry for the past five years. The high level of production required to meet the demand for proportioning control instruments has made is possible to substantially reduce the premium that was at one time paid for proportioning controllers, and now, since they cost little more than *On-Off* controllers, they are generally applied to processing where the process may not actually require the inherent accuracy of proportioning but will normally benefit from reduced temperature tolerance.

High limit controllers have been a standard instrument almost as long as *On-Off* controllers. They differ from *On-Off* instruments in that the control relay does not automatically reset after the true temperature reaches the control set point. Primarily used for over-temperature safety applications, they have many other applications as well. When used as a high limit safeguard, they are wired to hold in a contactor that is in series with the furnace or heater load. The control set pointer is then adjusted to be slightly higher than the desired operating temperature so the process is in no way affected by this instrument being in the control circuit as long as the process is normal. Should the process temperature rise above the desired value due to failure of the primary control instrument, a burned out thermocouple, or perhaps a stuck contactor, the high limit controller would automatically turn off power to the heater before the furnace and load is damaged. Since the instrument actuates a relay, it is also possible to sound an alarm or light a visual signal, calling attention to the fact that the high limit control has taken over. As this instrument does not automatically reset itself, the power to the heater will remain off until it is manually reset by the operator. Our high limit controller has the

added feature of a switch that permits the use of this instrument as either a high limit controller or an *On-Off* controller; thus, if it is being used as a safety over-temperature control and the primary system fails in the *On* position, it is possible to switch to the *On-Off* system and continue the process cycle as a manually controlled operation.

High limit controllers are also used in applications other than over-temperature controls. In the ceramic industry, for example, it is common to use such instruments to raise the temperature of a kiln to a particular value at which time the kiln has completed its processing cycle and the instrument turns off the power.

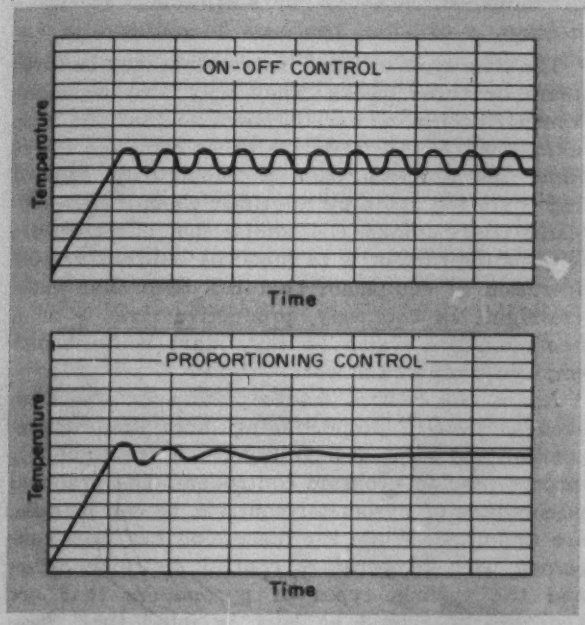


Fig. 4—Comparison of temperature-time plot of the same installation when controlled by an On-Off controller and proportioning controller.

Three-position controllers are quite versatile, as they are almost the equivalent of two *On-Off* controllers. In these instruments there are two relays that may be set to operate at two different positions on the temperature scale. The various possibilities that this will permit are illustrated in *Fig.* 5. In addition to the control functions indicated, it is also possible to incorporate proportioning action on either or both relay positions providing again a standard instrument for a special application. An application example can be taken from the plastic industry where this particular configuration is quite widely used in thermoplastic extruders in which heat of friction is not uncommon with some materials such as rigid vinyl. In this case, the extruder barrel is divided into zones and is controlled with three-position controllers incorporating proportioning control action on the low temperature relay. Since frictional heat is not always present, the temperature will be controlled normally with the inherent accuracy of the proportioning control action; however, should frictional heat cause an increase in temperature above the normal running value, the instrument can automatically become a cooling controller switching from no heat to cooling either by operating air cooling blowers or by solenoid actuation of a water or vapor cooling system. Since in this particular operation frictional heat may come and go and excessive temperature could be quite damaging, it is easy to see the utility of this versatile instrument.

▶ Ultimate Means of Control

Stepless controllers, as the name implies, can provide modulated power to a heater or furnace without the use of relays or contactors. While various methods are used by the different instrument manufacturers to accomplish this end result, the objectives are the same and this type of equipment provides the ultimate in fine control.

In our stepless controller, the power is modulated by means of a saturable reactor, *Fig.* 6. The pyrometer instrument which controls this reactor produces a direct current control signal that determines the amount of line power that is applied to the heater load. In end results, the accuracy of temperature that is obtained would be equivalent to what could be expected with the use of a rheostat or Variac on a stable power supply with a fixed load in the furnace which has been stabilized at temperature. The stepless type instrument provides for superior control since it is possible to come up to heat at greater power and the temperature is maintained without regard for voltage fluctuation or changes in the thermal mass which is being controlled. *Fig.* 7 shows the characteristics of stepless control and *On-Off* control illustrating how temperature is maintained in one case by switching power *Off* and *On* and in the other

APPLICATION	CONTROL FUNCTION BY INDICATING POINTER POSITION		
	BELOW BOTH CONTROL POINTS	BETWEEN CONTROL POINTS	ABOVE BOTH CONTROL POINTS
HEATING WITH AUTOMATIC COOLING	HEAT ON	HEAT OFF	COOLING
HI-LO-OFF	HIGH HEAT	LOW HEAT	OFF
HI-MED-LO	HIGH HEAT	MEDIUM HEAT	LOW HEAT
TEMPERATURE CONTROL AND HIGH LIMIT CONTROL WITH AUTOMATIC RESET	HEAT ON	HEAT OFF	HIGH LIMIT ALARM

Fig. 5—Three position controllers contain two relays which may be set to operate at different positions on the temperature scale. The chart indicates the switching arrangements that are possible with this type of controller.

by finding the exact power that is required to match the heat loss in the system.

One of the advantages of this type of control is its inherent stability. Should the thermal mass be changed, causing a temperature variation, it will be compensated for by a power correction in proportion to the temperature deviation, and as the temperature returns to normal, the power correction is reduced automatically to zero power.

Stepless controllers, because of their extreme accuracy, have been used to regulate creep test furnaces, transistor growing furnaces and many other precise applications in power ratings up to 150 kva. Occasionally they have been used to eliminate contactor maintenance and they have often been selected where the principal consideration was extending the life of electric heaters, where continuous operation at a low power level is contrasted to the thermal shock of turning heaters *On* and *Off*.

Relating Control To Time

Program controllers permit repositioning of the control temperature with respect to time. This is accomplished with mechanical linkage between a motor driven cam in the instrument housing and the control setting arm on the instrument. With the cam it is possible to raise the temperature, hold it for any period, cool at whatever rate is desired, hold at another temperature or accomplish whatever relationship is desired in the time-temperature program. Further refinements are possible. For instance, our program controller has a second cam that turns with, but is located behind, the temperature control cam and contains one or more actuators that will operate a snap action switch installed in the housing. By positioning these actuators, with respect to the time index lines on the master cam, other equipment may be turned *On* or *Off* as the cycle progresses. If the normal cooling rate of the process does not match the desired cooling rate, the snap action switch can be energized to introduce compressed air or start a blower. As another example of the versatility offered in programing, we have built one program controller which had eight actuators on the secondary control cam and, by positioning a stepping switch, controlled a sequence of process operations all synchronized with the same time cycle that was also adjusting the temperature as well.

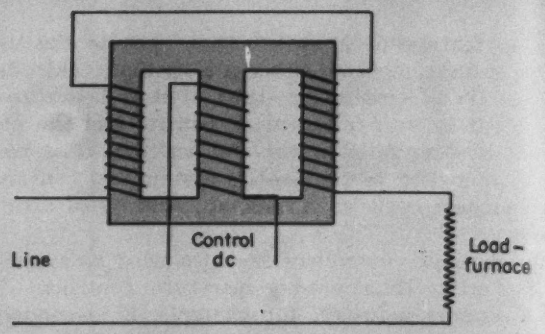


Fig. 6—Modulated power input to a furnace is provided by stepless controller which utilizes saturable reactor. DC control signal from pyrometric instrument varies line power without the use of relays or contactors.

The time cycle of these instruments may be three hours or three weeks. They may also be interconnected with industrial timers so that the snap action switch will introduce other complete cycles while the program cam is temporarily stopped and is started again by the timer when it has completed its functions. One simple, but effective, use for this instrument is to raise the temperature for operation of equipment that has been shut down overnight. In this way, productive time is at a maximum and warm up may start hours before employees report for work.

All of the control modes previously described, such as *On-Off*, proportioning, high limit, three-position and stepless have been, and are regularly, incorporated in program controllers. The practical possibilities of pyrometer controls, as can be seen, are unlimited. While the discussion has been concerned with temperature control instrumentation and the various types of pyrometers that are available, it should be kept in mind that these same instruments are equally adaptable to controlling many variables other than temperature. With transducers other than thermocouples, it is equally possible to indicate and control such variables as pressure, humidity, force, displacement, torque, pH, ac or dc current, voltages, etc. Uses to which the equipment can be put are apparently limited only by the ingenuity of the engineers who apply instrumentation. For persons with control problems which might be considered unusual, a word of advice is in order. Consider with caution, and consult instrument suppliers if you have a difficult control problem because the chances are quite good that there is a standard instrument built for, or adaptable to your need.

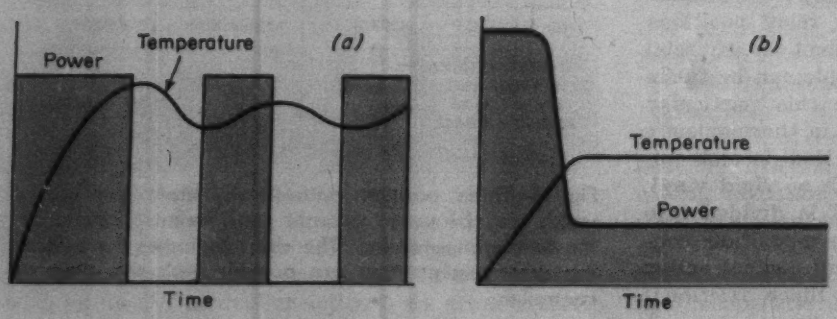


Fig. 7—Comparison of (a) On-Off and (b) stepless controller action in bringing a furnace up to and maintaining a set temperature. In maintaining a temperature with the stepless controller, a point will be reached at which power input continuously balances out heat losses in the system.

WORKPIECE HANDLING AUTOMATES STANDARD LATHE

WHEN TOOLING UP for a high production operation first consideration should be whether or not standard machines can do the job, then whether or not modifications of standard machines will do, and finally consideration of special equipment. Each consideration should be analyzed in the light of total cost.

As an illustration of the solution which involves addition of standard units to a standard machine, the Seneca Falls Machine Co. solved the problem of removing a welding flash on a worm shaft assembly by equipping their new model LN automatic lathe with certain standardized units to provide a specialized high production machine at substantial savings in initial cost and lead time.

Welded parts are delivered to the lathe directly from the welding machine by a conveyor adjacent to the loading chute. The hot parts move by gravity to the fixed stop at the loading position. At this point, an elevator assembly raises a rough piece over the loading-chute stop into the loading cradle which remains in the raised position until the part is injected into the collet chuck by the pneumatically operated plunger. The collet chuck closes, the elevator assembly retracts, the hinged steady-rest roll carrier automatically closes, the headstock spindle clutch is engaged, tools on the overhead slide advance to the cutting position, flash is removed and the area burnished, after which the tools retract.

On completion of a finish-turned part, the spindle stops, the hinged steady-rest roll carrier is retracted, the collet chuck opens and the finished piece is ejected from the collet by a spring loaded ejector rod. The part is deposited on unloader arms which swing the finished piece into the discharge chute and then return to the receiving position and a new cycle begins.

Loading, machining and unloading operations are entirely automatic. However, pushbutton controls are installed for manual operation of each movement. The loading cycle cannot get out of step since the automatic sequence is controlled by a system in which each movement is initiated by the completion of the preceding movement. Production of 275 pieces per hour is readily obtained with this equipment.

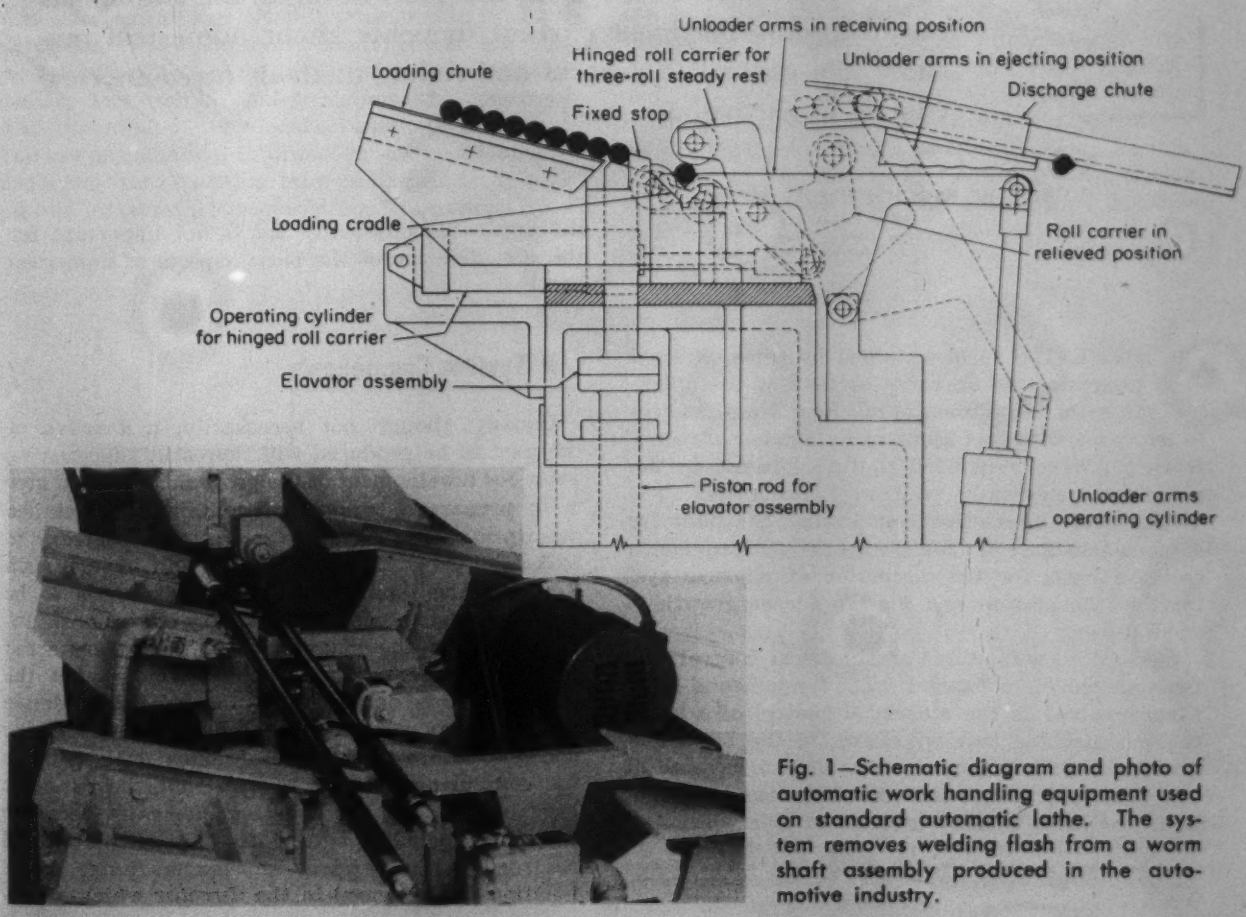


Fig. 1—Schematic diagram and photo of automatic work handling equipment used on standard automatic lathe. The system removes welding flash from a worm shaft assembly produced in the automotive industry.

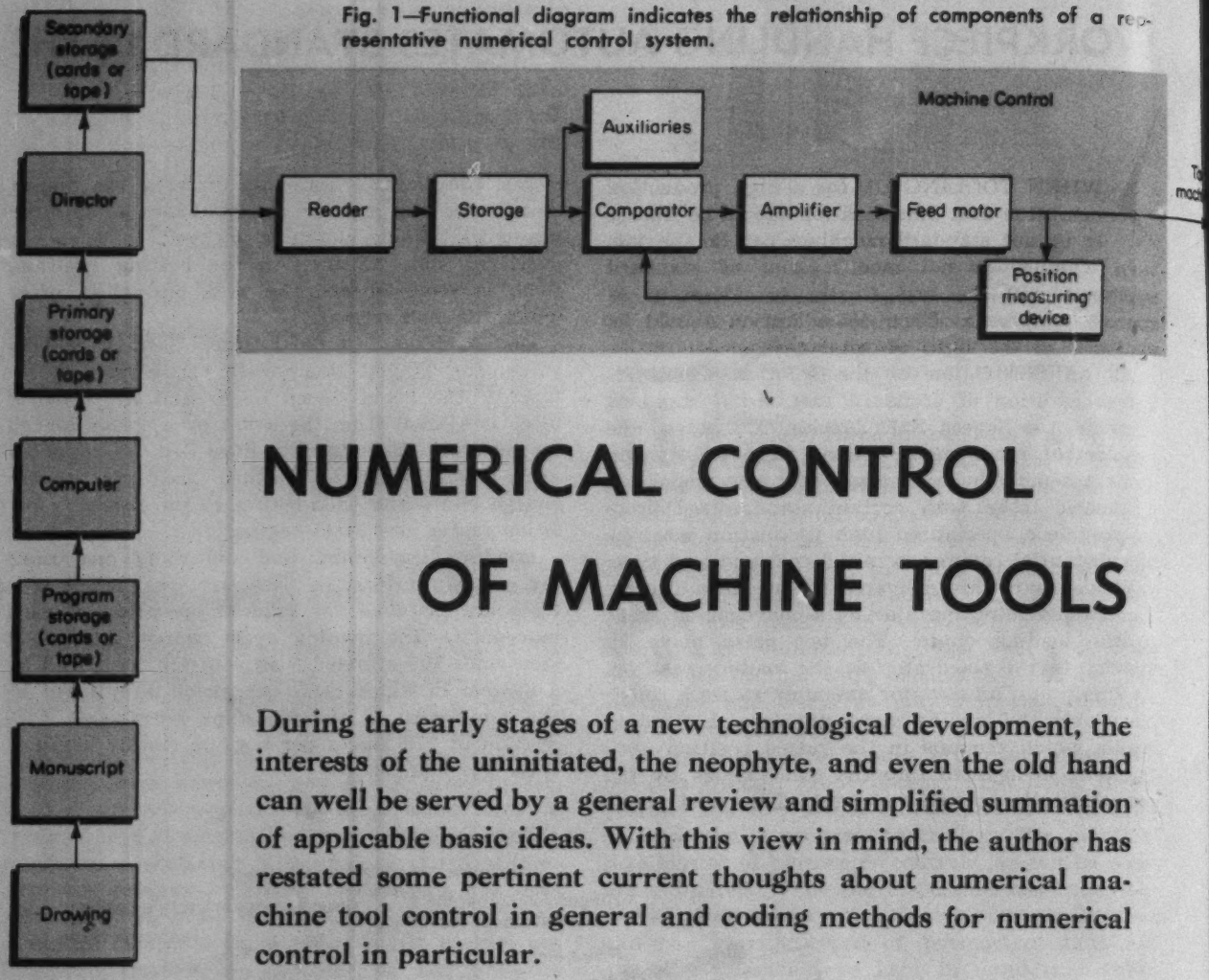


Fig. 1—Functional diagram indicates the relationship of components of a representative numerical control system.

NUMERICAL CONTROL OF MACHINE TOOLS

During the early stages of a new technological development, the interests of the uninitiated, the neophyte, and even the old hand can well be served by a general review and simplified summation of applicable basic ideas. With this view in mind, the author has restated some pertinent current thoughts about numerical machine tool control in general and coding methods for numerical control in particular.

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BENEFITS to be obtained by prior external programming on cards or tape of the operations of an automatic machine are attractive to many machine tool users, and a number of manufacturers have responded to this interest by developing numerically controlled machines. The diversity of these efforts emphasize the need for a consideration of fundamentals to provide a common basis for the discussion of physical systems in the present and for the proper growth in the future.

General classifications of numerical control systems are shown in TABLE 1. The fundamental functions involved in the numerical control of a hypothetical machine tool are shown in the block diagram of *Fig.* 1. Many systems do not have all of the functions listed and the functions may not be in the same relative locations. This will affect the apparatus physically but is not important for the consideration of the basic aspects of numerical control.

Article based on paper presented at the 20th Annual Machine Tool Electrification Forum, sponsored by the Westinghouse Electric Corp.

System Components

Usually, though not necessarily, a *drawing* of the part to be produced will represent the starting point for development of the program. The next step is to prepare a *manuscript* containing a detailed description of all machine operations necessary to make the part. This description will include such items as the tooling to be used, distances to be moved, feeds, speeds, and auxiliary operations. Information on the manuscript is then transferred to the *program storage medium* which takes the form of cards or tape and, for relatively simple systems, may serve as the input to the machine controls. More complicated systems, such as those for contouring, usually require that the cards or tape be fed into a *computing element* where the tool path, including cutter offset, is calculated and recorded in the *primary storage medium*. Interpolation is performed in the *director* which gener-

ates the *secondary storage medium* as the input to the actual machine control which is shown in the color area in *Fig.* 1. As part of the machine control, a *reader* is required to extract the information from the secondary storage medium. The data must be stored while being used by the control system; this *storage* may be accomplished by the reader itself or by internal storage in the machine control, according to the particular system.

At this point, position data from the *position measuring device* is fed to the closed loop systems controlling the machine motions. Since the actual machine motions are analog in nature while the data taken from the drawing is digital, a digital-to-analog conversion must, therefore, take place at some point in the programming or in the control system. The exact point at which this conversion takes place will depend on the individual system. It may occur at the last possible point, at the machine motion itself, but in some systems conversion is performed in the computing element so that the data in the secondary storage is analog.

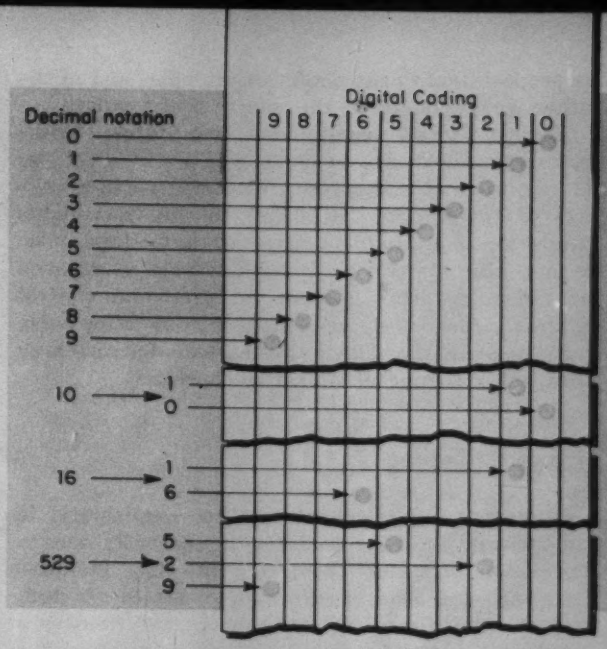

Fig. 3—In digital coding for control purposes, a ten-channel tape is necessary. With magnetic tape, the equivalent of the punched hole would be based on magnetization in one direction. This coding system enjoys the advantage of simplicity and the ease with which the decimal equivalent of the punched code can be recognized.

Control Signals

Numerical control implies the use of information in numerical or digital form as contrasted to that in analog form. Digital information implies information in the form of pulses while analog information implies continuity. The distinction is more subtle than this, however, since analog information can be and often is presented in the form of pulses. However, numerical signals are concerned only with a number of states of the signal—usually two—while analog signals are concerned with the value of some characteristic of the signal. The use of numerical information involves counting, while the use of analog information involves comparison of some characteristic of the signal to a standard. To illustrate, let us assume that a voltage signal is used to represent distance. In *Fig.* 2 both a direct voltage and an alternating voltage indicate a measure of distance in terms of voltage amplitude. For the alternating voltage, distance could have been made proportional to frequency or phase. All three methods represent analog signals. In *Fig.* 2 we see pulse signals which are also analog in nature. In one case the quantity of distance

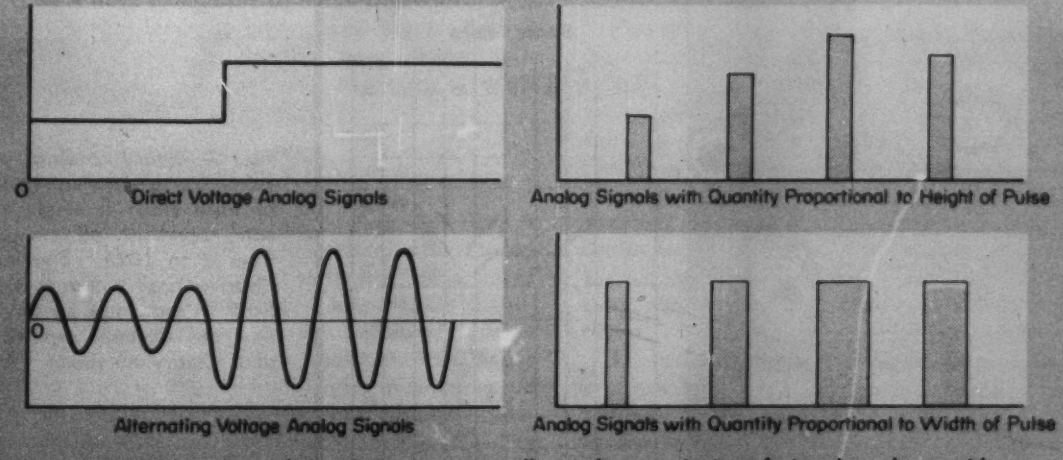
0
Direct Voltage Analog Signals
Analog Signals with Quantity Proportional to Height of Pulse
0
Alternating Voltage Analog Signals
Analog Signals with Quantity Proportional to Width of Pulse

Fig. 2—Though analog information normally implies continuity of signal, such as with a varying amplitude of direct or alternating voltage form as indicated, pulsed signals can also be used. As shown, varying heights or widths of a pulse can be used to indicate the desired change in value.

is proportional to the height of the pulse and in the other, proportional to the width of the pulse.

Digital signals usually have two states. These states may be the presence or absence of a voltage or a voltage of one polarity as compared to a voltage of the opposite polarity. Within reasonable limits the magnitude or shape of the voltage pulse is not critical; the permissible variation depends on the components used in the particular control system. The lack of sensitivity to reasonable variations in the signal is the basis for the high inherent accuracy of numerical systems.

Data Coding

Coding of numerical information, particularly in the primary storage medium, is currently receiving much attention from machine tool builders. Drawings and other design data generally use decimal notation for all whole numbers and there is a considerable trend toward use of decimal rather than fractional notations on drawings.

Since decimal numbers involve the use of ten digits, from zero to nine, to represent these digits mechanically requires that the mechanism have ten possible states. In desk type calculators, this is accomplished with gears having ten teeth, each of which represents one of the decimal digits. A comparable arrangement for punched cards or tape is to assign each of the decimal digits to one of ten positions and to indicate a decimal digit by punching a hole at a precise position, *Fig.* 3. A comparable arrangement for indicating decimal digits on magnetic tape or cards would be based on magnetization in one direction as equivalent to a punched hole, and no magnetization (or magnetization in the opposite direction) as equivalent to no punched hole. With a punched tape or cards this particular plan has the advantage that the operator can easily tell what number has been punched, but also has a disadvantage in that it is inefficient in making use of the full information capacity of cards or tape and control equipment.

Cards and tape — as well as such control components as relays, electronic tubes, magnetic and semiconductor devices — lend themselves readily to a two-state type of operation. This suggests the desirability of using numerical information in the binary rather than decimal form. In the binary system two digits, zero and one, may be arranged to represent any particular number. *Fig.* 4 shows how identical numbers are expressed in both systems, binary and decimal. Using an arbitrarily

TABLE 1

General Classifications of Numerical Control Systems for Machine Tools

According to function of the machine tool, control systems may be classified as:

Positioning Control. Simplest type of control. Only end points of travel are of interest and overshoot may be tolerated. Generally does not matter what path is taken between machine tool actions except to the degree that time required for travel is important. Example of application would be for drilling or punching machine control.

Straight-Cut Control. Position of tool must be controlled not only at the end points but at all points along the path of the cut. Can also contain feed rate control in which overshoot is not acceptable. When more than one machine motion is required, co-ordination of rates of movement is not a necessity. Example of application would be turning of stepped shaft in a lathe.

Contouring Control. Requires the programming of any tool path that can be generated by the machine motions. Usually simultaneous positioning control of two axes is present, including control of the feed rate. The necessity for programming the feed motions in small steps in order to follow arbitrary curves and the necessity for making corrections for cutter offset make contouring control much more complex than the other two types.

According to method provided for handling data, the control system may be classified as:

Incremental System. New position of a tool is given in terms of the distance and direction from the last position. An error in programming a given position will affect all succeeding positions. Power failure presents a problem in that the system may lose its memory of position, thus making it necessary to go back to some base point to pick up the program.

Absolute System. Specifies each position in terms of the distance and direction from some arbitrary base. An error in programming is not passed on to succeeding positions. Apparatus is not as simple and is therefore less economical and less reliable than in incremental system.

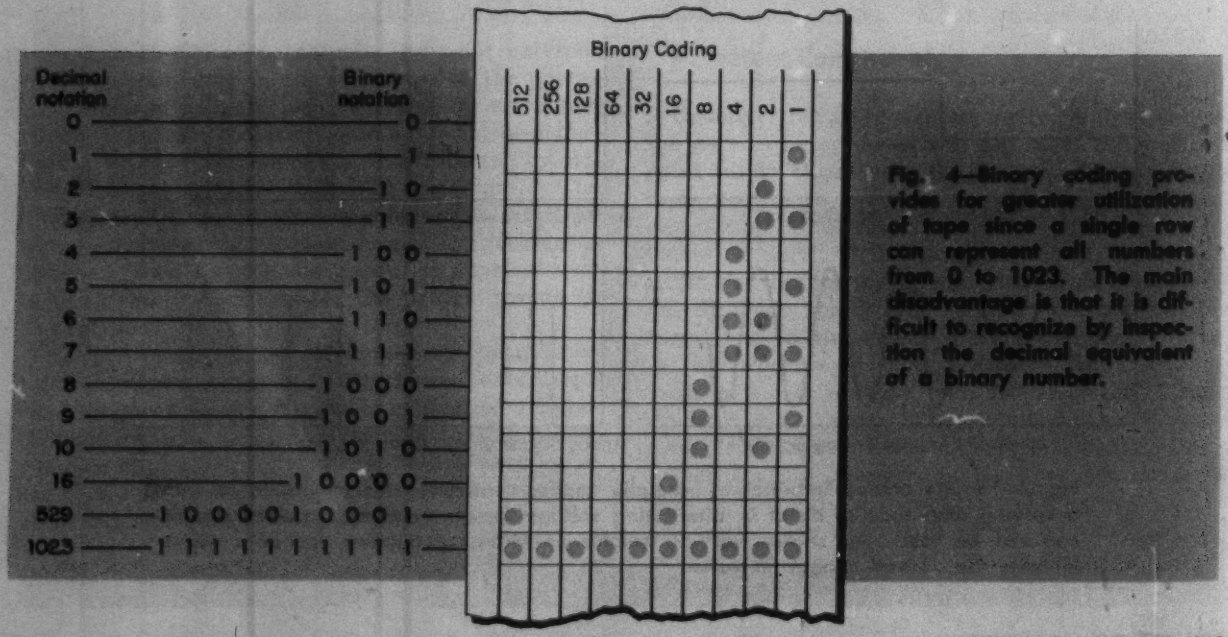

Fig. 4—Binary coding provides for greater utilization of tape since a single row can represent all numbers from 0 to 1023. The main disadvantage is that it is difficult to recognize by inspection the decimal equivalent of a binary number.

chosen number, 529, as an example it can be seen from *Figs.* 3 and 4 that while ten channels may be used in both the decimal and binary systems, the binary coding requires only one row while three rows are required for the decimal coding. As another comparison, three rows of the decimal system can be used to represent all numbers from zero through 999, while a single row in the binary system has the capacity to represent the numbers from zero to 1023. As a practical disadvantage,

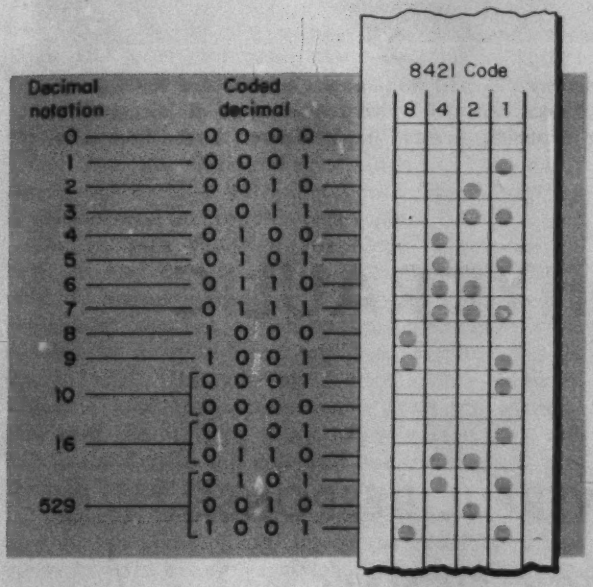

Fig. 5—Binary decimal coding combines best features of digital and binary coding. Numbers greater than nine are formed by proper combinations of four binary digits in the manner indicated.

however, it is virtually impossible for an individual to recognize by inspection the decimal equivalent of a binary number of any magnitude; in general, it is necessary to have a table of values, a pad and pencil, or a desk calculator to make this conversion. Further, when large numbers are involved it is difficult to transcribe binary numbers without error because of the monotony experienced when working with zeros and ones.

▶ Coded Decimal System

As a compromise between decimal and binary coding, binary coded decimal notation has most of the advantages of both and few of their disadvantages. This is known as the 8421 code and is illustrated in *Fig.* 5. For decimal numbers larger than nine, each of the decimal digits is represented by the proper combination of four binary digits, as illustrated for the number 529 in *Fig.* 5. The 8421 code is weighted; that is, a definite decimal value is associated with the "ones" in each of the four positions. By adding the weights associated with the "ones" in a particular coded number, the decimal value can be obtained. For example, the

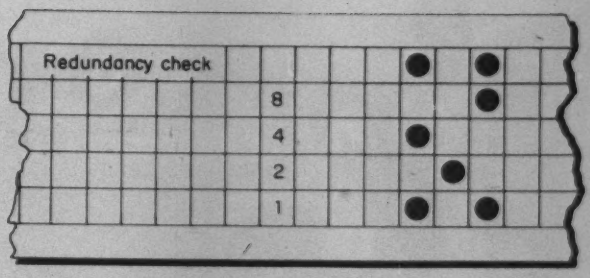

Fig. 6—A simple method of checking tape for errors during use is through the inclusion of redundant information. For instance, in the system indicated, a punch has been added to the tape wherever necessary to form an odd number of holes in a single row. With circuitry which registers odd or even number of holes in a row, it is possible to indicate error if an even number of signals per row is obtained.

number 529 in the 8421 code requires four channels and three rows, for a total of 12 possible hole positions. This compares with ten holes for the binary code and 30 holes for the straight decimal representation. Thus the economy of coded decimal notation approaches that of the straight binary code and considerably exceeds that of straight decimal notation. Further, the readability of weighted decimal codes is superior to that of the straight binary code and compares favorably with the straight decimal code. Decimal digits represented can be obtained easily by adding the weights or decimal values associated with the holes. An added advantage is that operators quickly develop the ability to recognize on sight the value of the numbers represented.

The 8421 code is not the only code that can be used; in fact, there are over 70 million ways in which the ten decimal digits can be represented by four binary digits. Even though only 17 of this 70 million are positive weighted codes, codes which are not weighted and those employing more than four binary digits are also of significance for numerical control.

Checking for errors is made possible through the inclusion of redundant information. For example, *Fig.* 6 shows the addition of a fifth row which is punched to insure that each column contains an odd number of holes. A single error will result in an even number of signals per column. Through circuitry designed to register odd or even numbers of holes it is possible to indicate that an error has been made. By more elaborate use of redundant information it is possible to check more than one error and actually to locate and correct errors.

At present, many varieties of machine control systems have been built which have incorporated some of these basic ideas. The future is certain to see many other new applications of numerical control designs which cannot be fully anticipated now. However, it is certain that the many varieties —past, present, and future—will have a common origin in principles which are fundamental today in the numerical control of machine tools.

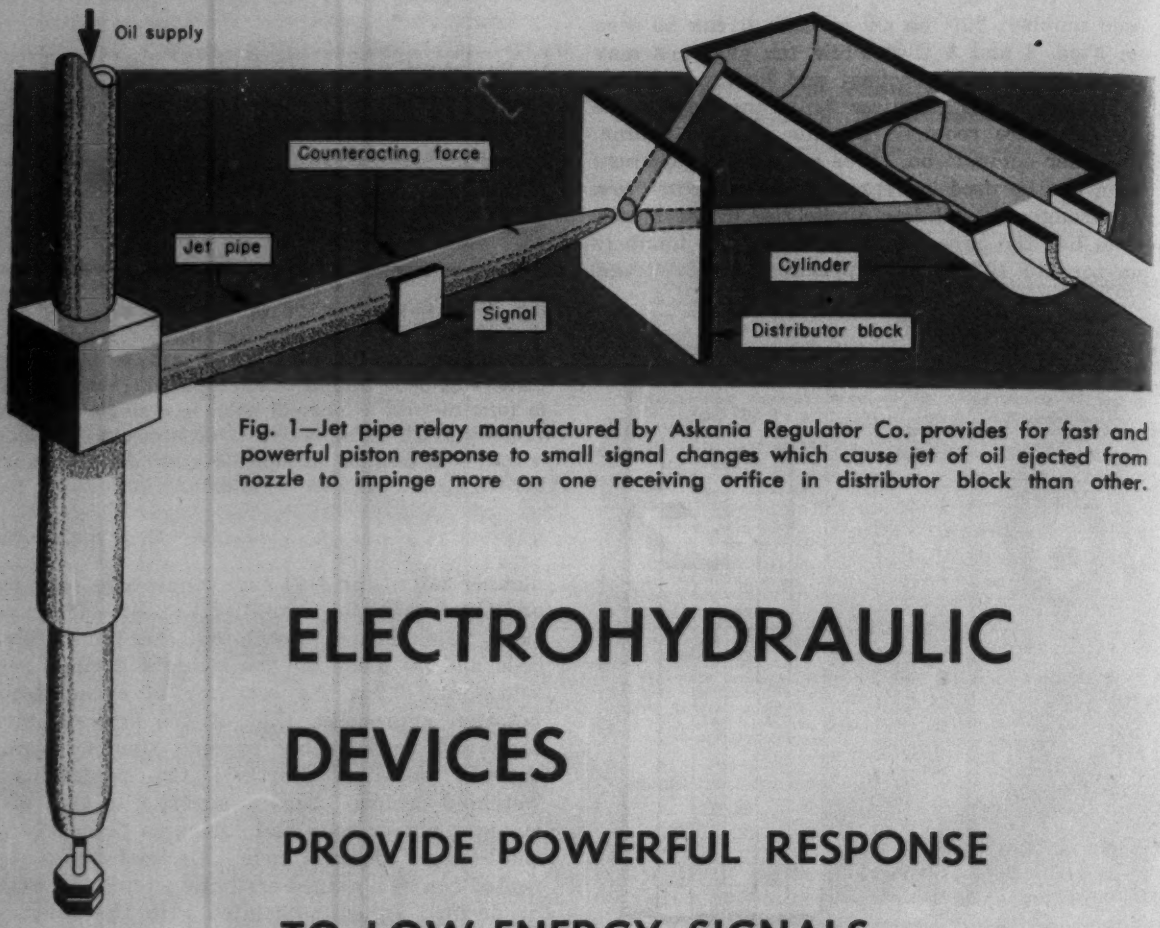

Fig. 1—Jet pipe relay manufactured by Askania Regulator Co. provides for fast and powerful piston response to small signal changes which cause jet of oil ejected from nozzle to impinge more on one receiving orifice in distributor block than other.

ELECTROHYDRAULIC DEVICES

PROVIDE POWERFUL RESPONSE TO LOW-ENERGY SIGNALS

By W. B. HEINZ
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Askania Regulator Co.
Chicago, Ill.

HYDRAULIC POWER devices combined with electrical signal systems are making a notable contribution to the instrument control field. The increasing interest of industry in electrohydraulics is due to the performance of a single system which incorporates the characteristic advantages of electric *and* hydraulic devices in measurement, control functions, and positioning power.

In regards to signal systems, transducers capable of delivering electric signals are available for all important variables. Measurements transformed into electric signals can be transmitted over great and small distances with nearly equal ease and quickness. Signal information in electrical form is suitable for automatic logging and computation, and for indication of desired control action. Speed; freedom from clogging, leakage and freezing; versatility and reliability — all are accomplished better by electric signal systems than by others for most applications.

Hydraulic power devices are singularly suitable for control purposes. When measurements in a system call for corrective action, generally low-energy signals must be able to command power to do work over wide ranges of force and speed. Hydraulic power devices readily provide rapid response, high speed, and large forces. The low inertia of hydraulic motors in providing linear and rotary motions; incompressibility of liquids; compactness of high pressure hydraulic power units; efficiency and freedom from heat generation; reliability, long-life and low maintenance requirements for hydraulic equipment — all participate in a combination of advantages unequalled by other power media for automatic control.

In electrohydraulic systems, requirements are such that between the electric signal system and hydraulic power unit, there must be a power amplifying link which partakes of the characteristics of both. The jet pipe relay has proved itself superior in this duty, *Fig.* 1. As can be seen from

the illustration, a jet pipe relay is primarily a nozzle which swings freely on a pivot and through which oil is pumped under pressure. The oil stream is directed at two closely spaced receiving orifices in a distributor block. These orifices are directly connected to the power cylinder. The jet pipe is supported at the base on a pivot or bearing and as its upper bearing literally floats in oil, its movement is practically frictionless. The adjustment signal is transferred into a force which tends to move the jet pipe from the center position in which the jet stream impinges at a point exactly between the two orifices in the distributor block. As the jet pipe moves, the stream ejected from the pipe impinges more on one receiving orifice, thereby creating a differential pressure across the piston in the cylinder. Superiority of this relay is based upon several important facts: There are no sliding valve surfaces; no small clearances to clog with dirt; no difficult bearing problems; and no trouble from wear.

The jet pipe relay can be made to respond to both ac and dc signals. *Fig.* 2 shows the heart of a dc signal element. It comprises a powerful permanent magnet which maintains a high flux density in a cylindrical gap. A moving coil is suspended in the gap by a leaf spring support which is also connected with a push pin in contact with the jet pipe relay. Power as low as 100 milliwatts drives the coil and connected push pin through its full stroke.

From this generalized description of the workings of the components, it will be possible to describe several examples which illustrate the versatility of applications of electrohydraulic systems. For example, the magnet and coil structure described for the dc signal element, drives a jet pipe in an electrohydraulic valve actuator, *Fig.* 3. The jet pipe is supplied with oil at 230 psi from a self-contained pump. An electric signal of less than

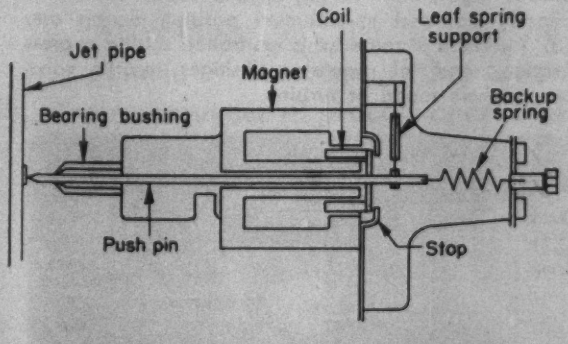


Fig. 2—Signals in the dc system are translated into linear motion necessary to move jet pipe in the relay by illustrated magnet and coil arrangement.

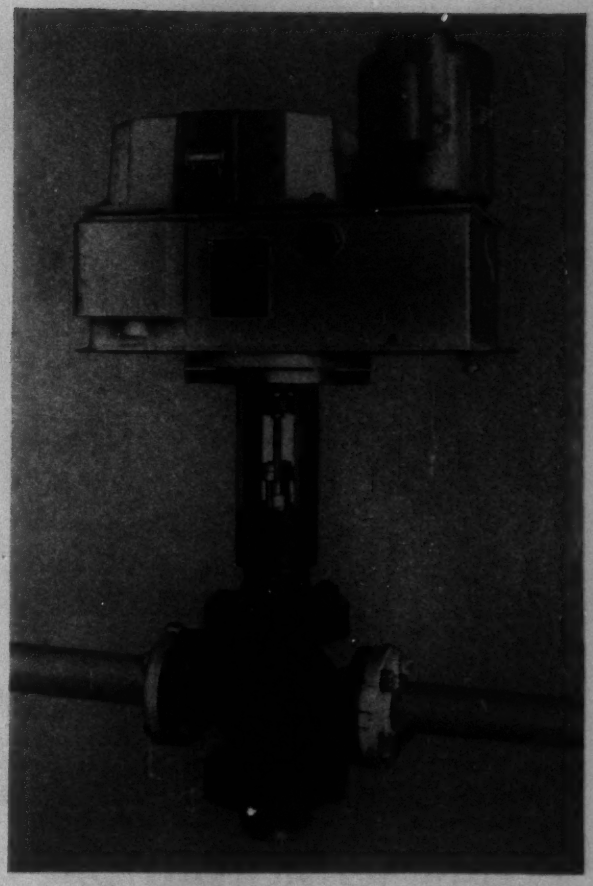


Fig. 3—In electrohydraulic valve actuator, jet pipe relay is supplied oil at 230 psi from self-contained pump. Unit shown responds to dc signals and actuates valve by piston and cylinder integrally mounted with unit.

0.1 per cent of full range initiates movement of the piston in the cylinder integrally mounted within the enclosure on top of the valve. A mechanical position feedback balances a coil force over a piston stroke adjustable from 0.5 to 2.0 inches. Frequency response is such that at the 2-inch stroke setting, the piston follows a 0.5 cps input signal with amplitude ratio of not less than 0.7. The piston stalling force is 1200 lb.

Loads larger than this, almost without upper limit, are handled by separately mounted hydraulic cylinders. Their oil supplies are manipulated by regulators of several models, a widely used one is shown in *Fig.* 4. It includes an integral hydraulic power amplifier or booster for power levels higher than those of jet pipes alone. In this regulator, an alternating current torque motor strokes the jet pipe; however, the torque motor can be replaced by a dc signal element.

Such a regulator with a dc signal element has been applied to electric arc furnace control, *Fig.* 5 (*a*). This development achieves superior arc furnace productivity and efficiency through higher speed and stability in electrode positioning. The moving coil signal element for this installation carries a double winding — one each for arc cur-

Fig. 4—Jet pipe in this Askania regulator responds to signals through ac torque motor. Unit also contains an integral hydraulic power amplifier to obtain higher power levels than available with only jet pipe relay.

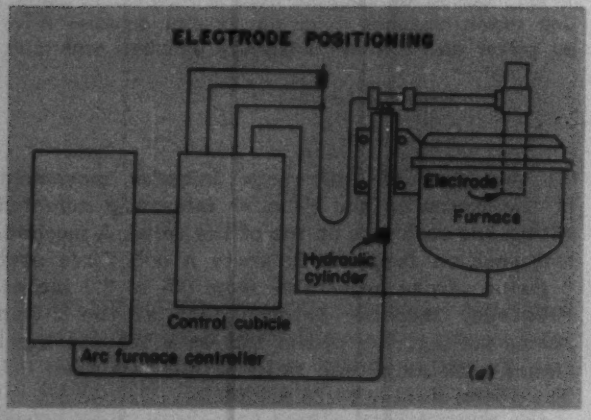
rent and voltage, rectified.

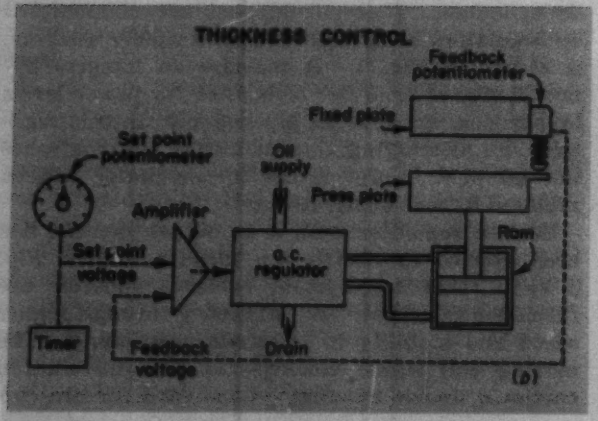
Another application automatically controls the thickness of material being cured in a hydraulic press, *Fig.* 5 (*b*). Desired thickness is selected by means of a set point potentiometer. Low pressure and high pressure pumps supply oil in parallel, closing the press rapidly until a low pressure relief valve opens, and the check valve closes. Thereafter the high pressure pump slowly compresses the material between the fixed and floating plates until a feedback potentiometer matches the set point potential. The regulator then holds the press in that position until the timer has passed the desired curing time. Oil is then released to drain by the regulator, the press opens, the product material is automatically advanced and another pressure cycle is started.

The Electrojet regulator has also been applied to speed control problems. A high speed turbine, as an example, drives a heavy duty tachometer generator whose output energizes a dc signal element driving a jet pipe in a regulator, *Fig.* 5 (*c*). Oil from the jet pipe moves a throttle valve to hold constant turbine speed. The auxiliary cylinder shown with the regulator in the illustrations provides proportional plus preset control of action, combining stability and zero offset.

In still another application, automatic control of electric power drawn by compressors and pulverizers is used to maintain desired operating conditions. In electrically driven centrifugal compressors, the motor power is directly related to the air flow. Instead of measuring air flow directly, it is frequently better to apply the motor voltage and current to a multiplying signal element driving a jet pipe relay. Hydraulic forces are thus applied to vary damper position or compressor speed for constant power. Feed to pulverizers is similarly varied.

Machine tool elements are positioned with maximum speed and accuracy by Electrojet regulators driving rotary hydraulic motors. The high torque-inertia of these motors permit rapid starting and stopping not attainable with electric motor drives. In this type of installation, substantially any degree of automation and accuracy can be had with punched tape programming and digital computing of information so far as the regulator signal element is concerned.





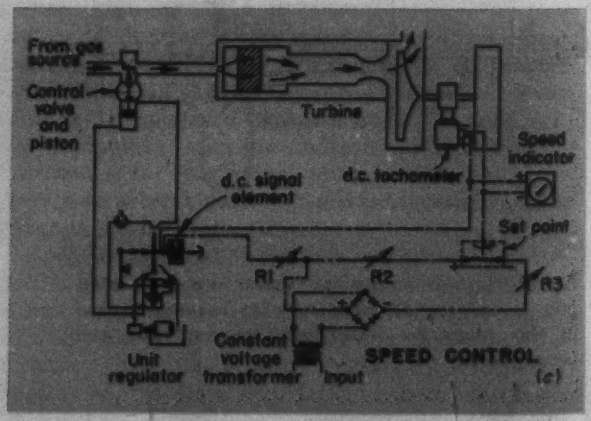


Fig. 5—Examples of industrial applications using electro-hydraulic regulators. In (a), carbon arc in furnace is constantly adjusted to optimum position during use; in (b), thickness of material is controlled during a press operation; and (c) regulator positions throttle valve which controls speed of turbine.

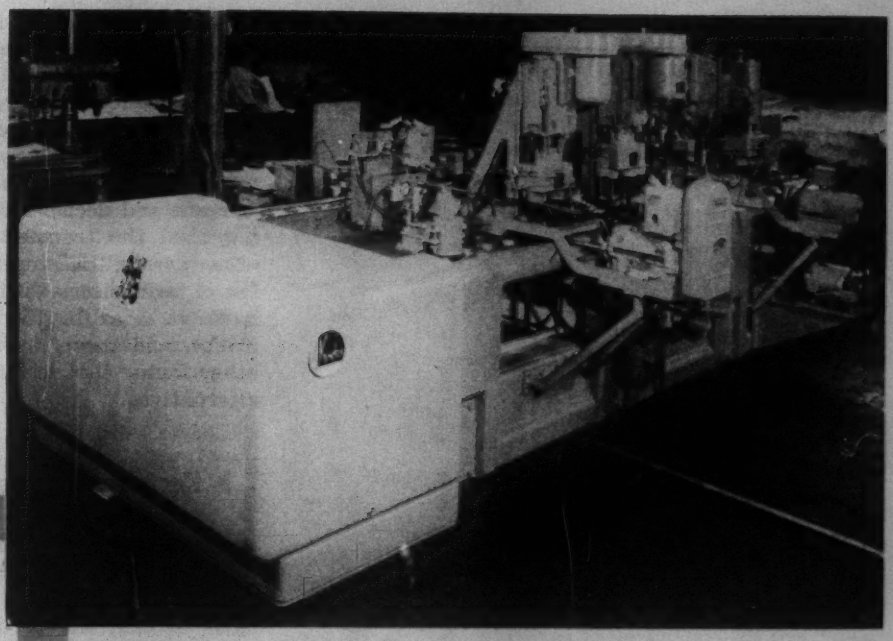


Fig. 1—Pallet type transfer machine adaptable to be tooled for either automated sequence machining operations or automated assembly processes. Machine pictured is tooled to perform drilling, counterboring, burring, tapping and milling operations on diecast aluminum disks.

BASIC TRANSFER MACHINE

HAS ELECTROHYDRAULIC ACTUATION OF PALLETS

By George H. Kendall, Sr.
Jerry A. Host
George H. Kendall, Jr.
Kenhos Corp.
Norwalk, Conn.

Acceptance of the multistation principle of accomplishing an entire sequence of process operations on one machine has led to the development of standardized transfer machines. Design attention has been focused on providing basic equipment for transferring workholding pallets around the perimeter of a table which mounts tooling attachments that can be replaced for various machining and/or assembly processes.

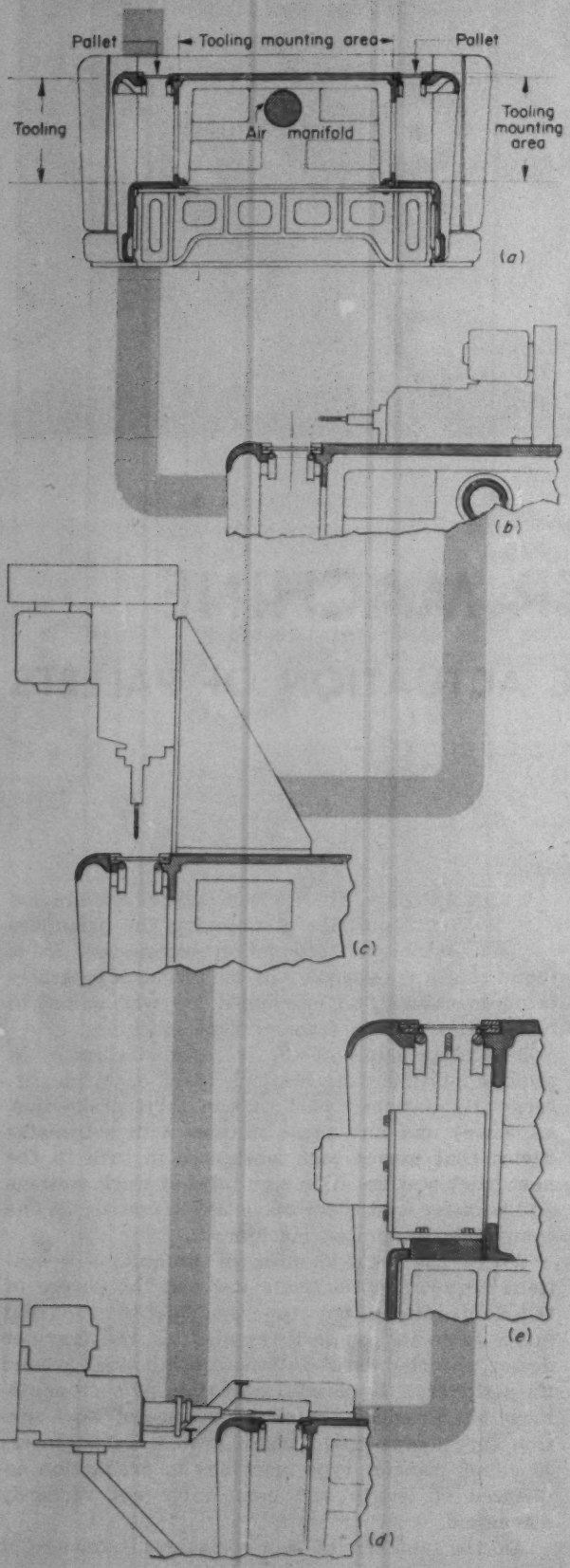
AS PRODUCTION PROCESSES are studied with the purpose of applying the principles of automated production techniques, it is found that a wide variety of the products presently being machined and assembled are well suited to being processed on transfer type machines.

General principle of the transfer machine is to provide multiple work stations (each of which performs its assigned part of the total production sequence) and link these stations with a transfer device that moves each workpiece in turn to the next work station. The sum total of work stations and transfer equipment are made to operate as one completely integrated machine.

Where the total number of production operations required is relatively low and the nature of these operations not too complicated, the dial index table is popularly applied as the transfer device and the work stations are mounted around its periphery. Successful operation of such equipment has provided proved techniques of work station functioning that inspire processing engineers to adopt transfer type machines to production sequences of length and complexity not formerly attempted.

As the number of work stations increases it

Fig. 2—Cross section sketches of the transfer machine base shown in *Fig.* 1. Relative positions of pallets and tooling mounting areas *(a)* provide that tooling attachments can approach the workpieces from four sides: *(b)* within the pallet perimeter, *(c)* above the pallet, *(d)* outside the pallet perimeter, and *(e)* below the pallet.



becomes necessary to increase the diameter of the index table to provide more perimeter for equipment mounting. This requires a corresponding increase in the number of holding fixtures or work nests that are mounted on the table. When the point is reached where the total mass of table and tooling mounted thereon becomes difficult to accelerate and decelerate in a reasonably fast indexing time the transfer machine designer looks to other possibilities to accomplish the desired transfer of workpieces. King-size dial table diameters have an area in the center that is difficult to utilize, and the efficient use of floor space is another factor that leads to consideration of possible alternatives.

▶ Rectangular Transfer Base

Rather than move the whole table top to accomplish the index it is possible to mount the work nests on carriers or pallets that can be made to move around the periphery of a stationary table top. This idea results in less mass in motion during index. If the table is made rectangular instead of round the area consumed to provide a given perimeter requirement is reduced. These considerations provide the fundamental design configuration of a basic transfer machine that is being used to an increasing extent for automated sequence machining and automated assembly operations. The Kenhos Corp. has designed a basic machine of this type, *Fig.* 1.

Such machines are termed basic because they provide the transfer mechanisms to move a number of pallets through the transfer cycle and provide also tooling mounting areas upon which tooling attachments may be fastened to perform the sequence of operations required by any of a wide variety of machining or assembly processes. This enables a given machine to be tooled for different production runs.

In order to provide the greatest flexibility of potential applications, certain features of the base of the machine should be considered. A cast iron table mounted on cast iron frame rails provides strength and rigidity consistent with the best standards of machine tool building. A modular design of center section allows multiples of such sections to be bolted together between standardized base ends and attain the required overall machine length. The process engineer can combine operations and perform various actions simultaneously at a savings of overall machine length and an achievement of greater accuracy of operation if the pallet is well supported and accessible from all directions. To accomplish these performance objectives the side rails are made to support the outside of the pallet and shaped such that tooling attachments can be mounted below the pallet. *Fig.* 2 shows how tooling attachments can be mounted in various positions relative to the position of the pallet. The base also incorporates an air reservoir manifold with connections such that pneumatic devices can be readily hooked in at any tooling station.

Transfer Mechanism

Production cycle time on this type of equipment is the sum of the time required for the transfer mechanism to cycle and the time required for the slowest work station to complete its cycle. The former is a built-in attribute of the basic machine while the latter is dependent on the operations the machine is tooled to perform. Since the transfer time is considered as unproductive time it is desirable that it be kept at a minimum. The transfer mechanisms described in *Fig.* 3 on a machine equipped with 6 x 6-inch pallets, requiring a 6-inch stroke, are designed to cycle at a fixed time of ¾-second.

High-speed transfer requires controlled acceleration and deceleration if the pallets are to be moved without imparting severe shock that would tend to dislocate the workpiece in the nest. This design uses pallets with length limitation 0.035-inch shorter than the distance between the pins on the transfer bars. The pins behind accelerate the pallet and the pins ahead bring it to a stop. This arrangement provides that the leading edge of each pallet will stop in a consistent position with respect to any given work station because the same sets of pins on the transfer bars reciprocate in service of the same work station all the time.

Requirements of the transfer mechanisms include accuracy as well as speed. Any arrangement of multiple pallets has inherent variations due to the fact that the toolmaker must be allowed a certain amount of tolerance in the construction of the pallet and the work nest mounted thereon. These tolerances accumulate with the tolerances used in making the transfer bar with the result that workpieces on successive pallets will vary in position with respect to a fixed reference point on a work station.

Design of the transfer mechanism and the physical arrangement of the tooling mounting areas can go a long way toward minimizing the effect of accumulated position errors. Where accurate location of drilled holes on workpieces is a requirement of the process these may be drilled simultaneously by drill heads in different positions using one common drill bushing plate, *Fig.* 4.

With the small clearance between the pallets and the transfer pins allowing a bit of float for each pallet, the small differences between pallet sizes can be eliminated from the accumulation of position errors by equipping each pallet with tapered bushings pressed in precise location with respect to the workpiece locators. Tapered plugs in the fixture clamp plate engage the bushings and establish the required position, *Fig.* 5.

Where high precision is required, tooling attachment arrangements can be devised that work in conjunction with this basic machine to produce accuracies in the order of tenths of thousandths of an inch.

Electrical Operating Control

It has been mentioned that the primary requirements of the physical configuration and mechanical layout of a basic transfer machine are to provide for: (1) The intermittent indexing of work nests, and (2) the attachment of tooling stations to operate in conjunction with the transfer system. The electrical control system of the basic machine must also make provision for these same requirements. The transfer mechanism must cycle automatically and be interlocked with the control circuits to each of the tooling attachments.

One end cabinet of the Kenhos transfer machine houses the control equipment for the machine and has a pushbutton panel that consists of switches to start, jog, run, and cause emergency stopping of the machine. Also included are a single dial variable-speed control plus a machine-attachment

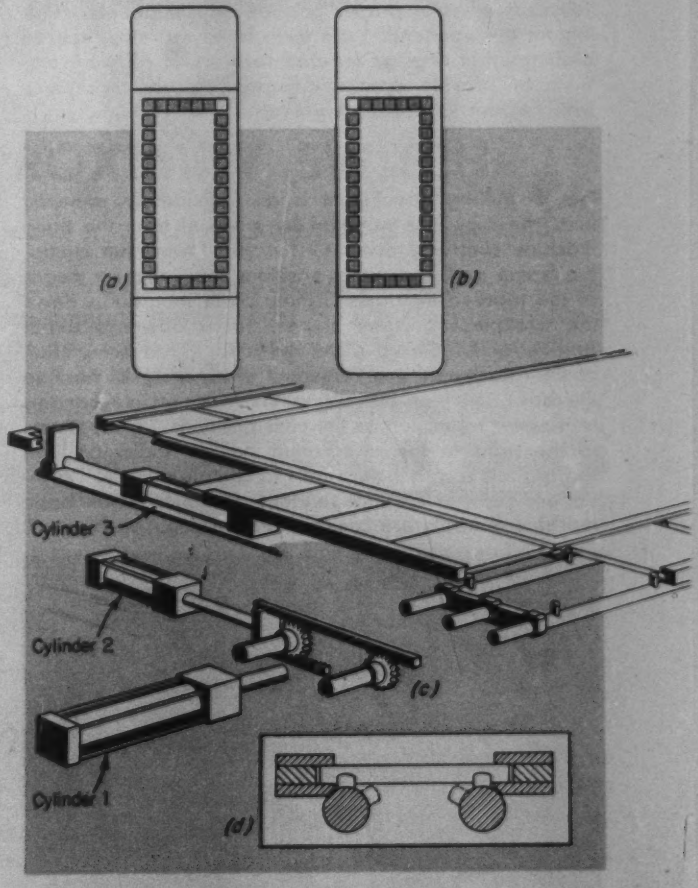


Fig. 3—Details of transfer mechanisms and operating cycle. Sketch *(a)* shows position of pallets during time the attachments are cycling and transfer device is at rest. Sketch *(c)* shows linkages which are in both end cabinets of machine. Upon actuation of transfer cycle, rods of cylinders 1 extend to push pallets on each side forward into position shown in sketch *(b)*. At this position rods of cylinders 2 retract—causing transfer bars to rotate and drive-pins to clear underside of pallets as shown in sketch *(d)* which is a cross section through the transfer bars between two pallets. Rods of cylinders 1 then 2 return to original position so that cylinders 3 now retract, pushing pallets across the ends of the machine, then extend again completing the transfer cycle by returning all elements to original positions *(a)*; except for the pallets, which are now one step advanced.

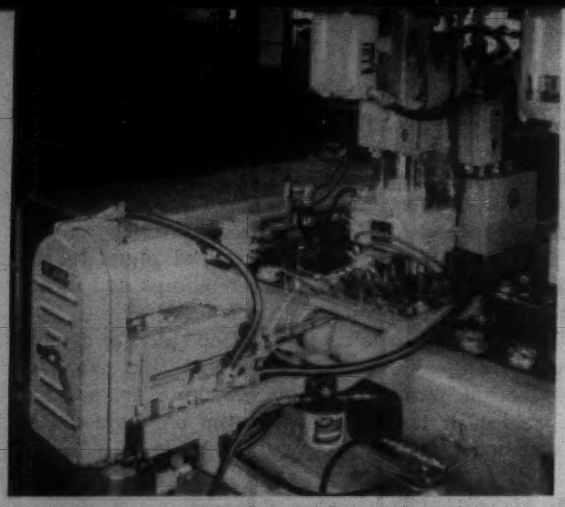


Fig. 4—Work station shows tooling attachments mounted in combination to perform critical operations simultaneously. One multispindle drill head covers two pallets and drills patterns of holes from above. One single drill spindle comes in horizontally. One drill bushing plate serves both horizontal and vertical drills. Work station visible to the left is a mount for a pallet cleaning system that prepares the pallets for workpiece loading in the space between stations.

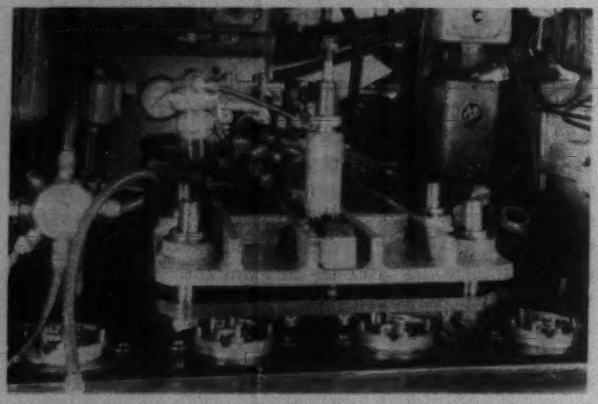


Fig. 5—Where tooling attachments are underneath the pallets and tool pressures push up from below, the work station above is equipped with holding plates that keep the parts in proper position on the pallets. Pallets for this application are each fitted with two tapered bushings that engage tapered locators at all work stations to provide precision location of the workpiece with respect to the cutting tools.

Fig. 6—Milling attachment is an individually powered unit whose cycle is initiated by a signal from the basic machine control circuit. First action lowers the clamping frame and accurately positions the pallet by means of the tapered locators. Clamp plate then holds down the workpiece. Cutter spindle feeds down to depth and retracts. Clamp plate retracts. Upon completion of the attachment cycle this unit sends a signal back to the basic machine permitting the indexing mechanisms to transfer all pallets to the next positions. Control box to the right of the attachment has an indicator light that signals if attachment fails to complete cycle. Pushbuttons provide for independent operation when basic machine controls are set on *Machine Jog*.

control. This latter control changes all tooling attachments from interlocked automatic operation to individually controlled operation.

The variable-speed control adjusts the dwell time between initiations of the transfer cycle and thus provides for production cycles of different length. Each unit of tooling attachment that is employed in a particular setup has its own electrical control panel within the attachment. These units plug into the basic control circuit and upon completion of the transfer cycle are signalled to commence their own cycle. As each of the attachments completes its cycle it so signals the master circuit. When this master timing circuit is again ready to initiate the next transfer cycle it can do so only if all attachments have signalled their state of completion, *Fig.* 6. Should an attachment not complete its cycle for any reason the individual panel will show a visible signal and the master base circuit will shut the machine down.

This plug-in system of connecting attachments to the control circuit of the transfer base provides flexibility for the use of various numbers of attachments—up to the number of outlets provided in the base. The system also provides for the easy incorporation of probing or sensing stations that verify that proper conditions exist in order that jamming of the mechanisms or processing of defective parts will not be permitted.

▶ Tooling Attachments

There is seemingly no limit to the number of different types of tooling attachments that can be mounted to the basic transfer machine. This equipment is designed to handle machining and assembly of small parts, and provides space for mounting drill heads, boring spindles, milling attachments, and gaging equipment of size and capacity consistent with the designed purposes of the machine.

Variations of the basic design enable the use of coolant pumping, removal and filter systems and chip collection arangements.

Assembly stations including hopper-feeder, tracking, escapement and insertion devices to satisfy a full range of assembly process requirements can be adapted to the standard transfer base.

This basic transfer machine takes its place as equipment available to the processing engineer, on which can be built fully automated production processes.

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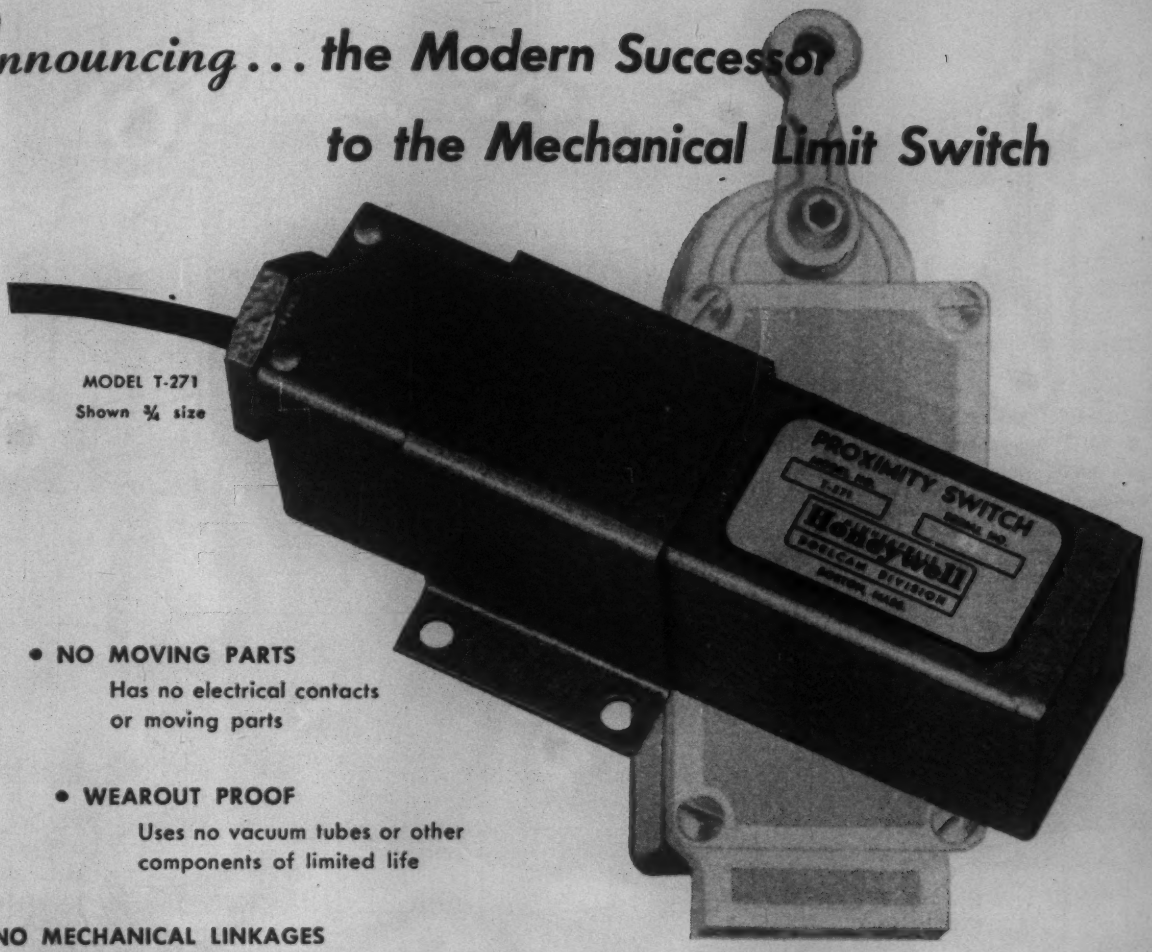

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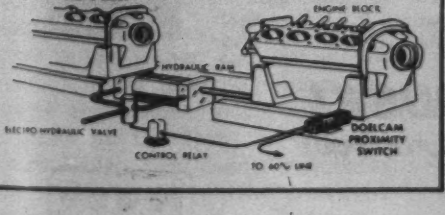

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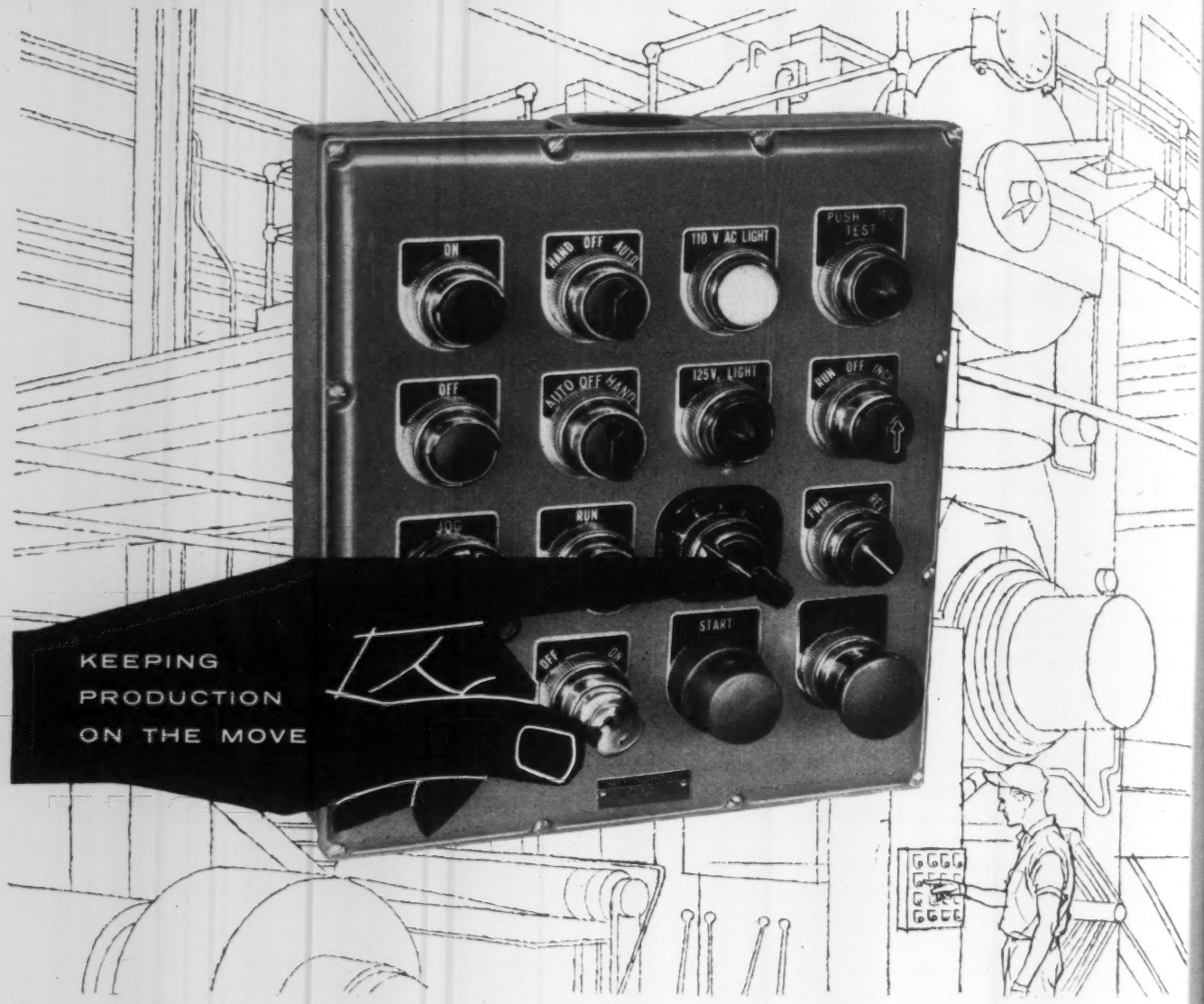

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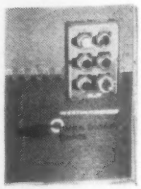

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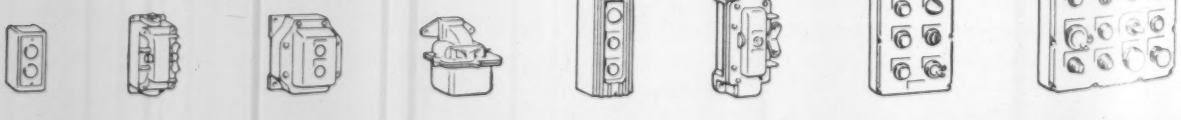

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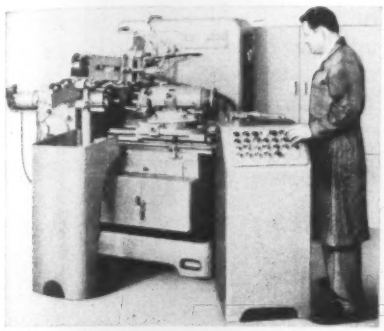

Gear Loader

Designed for handling spur or helical internal gears on shaving machines, automatic loading device solves a difficult automatic loader design problem — that of meshing the teeth in an internal gear with those of the helical gear shaped shaving cutter. An intermediate air-powered loading sleeve mechanism which receives the internal gears one at a time from a magazine feed, hangs them on the cutter and provides the meshing problem solution.

In operation, internal gears to be shaved are loaded in a magazine where they roll by gravity to a position in front of an air-powered plunger. The plunger pushes one gear at a time into the loading sleeve, which is mounted on a swinging arm and swung through an arc by an air cylinder controlled linkage. The pushing of an unshaved gear into the sleeve at this raised position causes a finish-shaved gear in the other end to be deposited in an unloading magazine where the shaved gears roll to a location at the front of the machine. In the next loader sequence, the sleeve holding the unshaved gear is swung downward by the air cylinder into line with the work spindle center line. A finish-shaved gear in the chuck on the workhead is ejected by another air cylinder into the sleeve. Entry of the finish-shaved gear ejects the unshaved gear in the other end of the sleeve into mesh with the shaving cutter where it remains hanging on the cutter. Then the loading sleeve is raised back to the load position. The internal gear and shaving cutter are then advanced as a unit toward the chuck in the workhead and the gear is chucked, ready for the shaving operation with the cutter in mesh with the gear. **National Broach & Machine Co.**, 5600 St. Jean Ave., Detroit 13, Mich.

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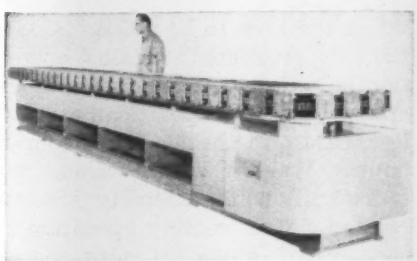

Indexing Chassis

Designed as a standard indexing machine chassis for special purpose and automatic machines, Auto-Tran is available as a continuous motion unit for various processing and manual assembly operations requiring this type of chassis. The chassis construction for the continuous running unit features a variable speed transmission and reducer which replace the cycloidal cam indexer. The rate of carrier movement is infinitely adjustable, and is remotely controlled and tachometer indicated.

Illustrated continuous motion Auto-Tran is 21 ft long, with 62 carriers on 9-inch centers. Carrier movement is from 2 to 8 fpm. Standard carriers or pallets may be vertical faced as illustrated, or horizontal. **Swanson Tool & Machine Products Inc.**, Erie, Pa.

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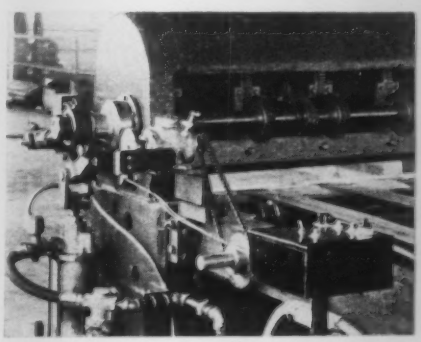

Length Controller

Designed for variable length cut-off to high accuracies, Model 30A length controller is used to cut to length a variety of materials including textiles, veneer, rubber, glass, wire and plastics. It provides length control of strips, tapes and sheets of all types.

Input of the length controller transmission is connected to a conveyor head shaft, a draw roll shaft, a capstan or other shaft which controls the rate of feed of the material. A cam mounted on the output shaft of the unit trips a limit switch or valve which controls the cut-off knife. Unit is chain connected to a drive roll of the machine.

Length control from a fraction of an inch to several hundred feet is available. The micrometer dial may be calibrated directly in inches. Once set, length control remains the same. Remote mechanical or electrical controls can be furnished, providing high accuracies of length settings. **Graham Transmissions Inc.**, Menomonee Falls, Wis.

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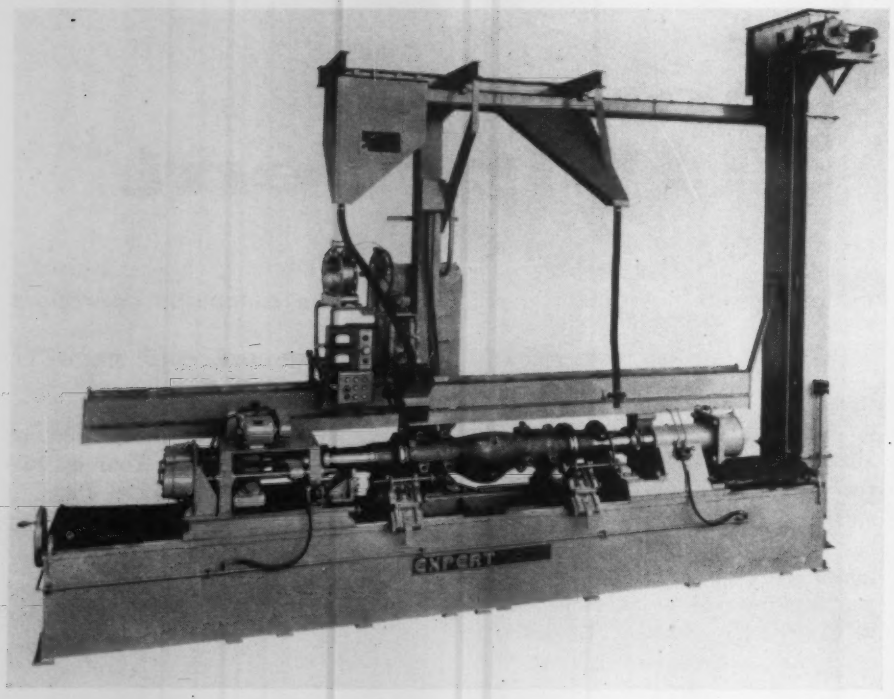
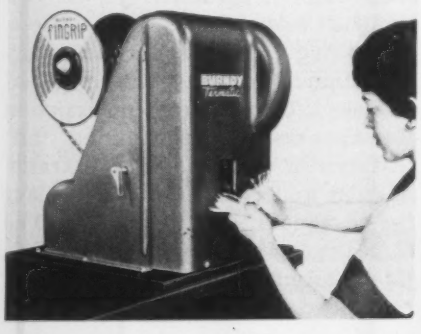


Shielded Arc Welding Machine

Designed for producing circular welds on large, round assemblies up to 13 ft long, machine welds flanges on each end of earthmoving equipment axle housings. Welder has 19-ft long steel bed which supports a variety of fixtures that are moved along the bed to suit assembly length variations. Fixtures have motor driven headstock, tailstock with live centers, rest blocks for supporting parts during loading and roller-steady rests that support the parts during welding. Air cylinders control the axial motion of both head and tailstocks. Conventional submerged arc welding equipment is mounted on ways on the new machine. Mechanical type flux recovery unit and preheating units are also provided. To operate machine, circular parts to be welded are positioned on the fixture rest blocks. The head and tailstock centers are advanced by their air cylinder controls to hold the parts firmly in correct location during welding. Welding head is positioned axially to proper location along the assembly to be welded by moving it along the ways manually and clamping it in position with a hand clamp. Pushbutton controls for the two motor drives on the head bring welding head to correct vertical and forward location. Fractional horsepower motor and lead screw drives power in and out, and up and down head motions. When welding head is positioned, assembly is rotated by a ½ hp motor drive during the preheating and welding operation. When the area to be welded is sufficiently preheated, welding operation is initiated. During this operation, flux is automatically gravity fed to the weld area from a hopper. Welding wire advances automatically while assembly is being rotated. This welding operation is continued for one or more passes until the desired amount of weld deposit is attained. **Expert Welding Machine Co.**, 17144 Mt. Elliott Ave., Detroit 12, Mich.

Circle 404 on Inquiry Card

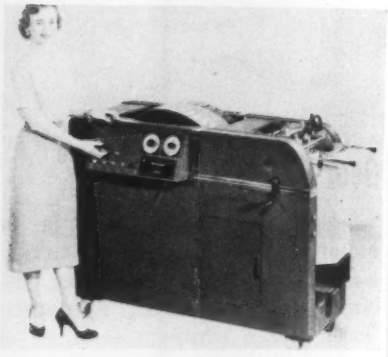


Termination Machine

Termatic is name of new machine which automatically connects wire sizes 22 through 12 to a quick disconnect terminal called the Fingrip. With this easily loaded machine (less than 15 seconds loading time), terminals can be installed at the rate of one every 3/5-second, or 6000 per hour.

Connection is fully automatic, with no pedals or levers to press and no prepositioning of the wire necessary. Insertion of the wire actuates the Termatic. Machine is completely enclosed for operator protection and has no exposed parts. Fingrip terminal has four individual pressure elements, permitting greater flexibility and abuse without damage. **Omaton Div., Burndy Engineering Co.**, Norwalk, Conn.

Circle 405 on Inquiry Card



Collator

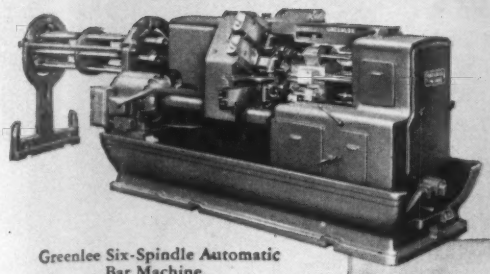
With an operating speed of 6000 per hour, Accra-Feed machine is well suited to the collation of such jobs as parts catalogs, price lists, bulletins and booklets. Electronically controlled collator automatically assembles, in one continuous machine run, 50 complete sets of material up to 100 sheets each.

Collator is a compact unit that occupies less than 13 sq ft of floor space. Feature of the unit is its 50-pocket drum which takes sheet sizes from 4 by 6 inches up to 11 by 14 inches. The pockets automatically advance one station at each revolution of the machine. The automatic controls include one that eliminates blank sheets, another that rejects double sheets, and a third that prevents skipped sheets. Standard equipment also includes a large capacity vacuum paper-feeder, a sheet counter, a book counter and an automatic stop. **Addressograph - Multigraph Corp.**, Cleveland 17, O.

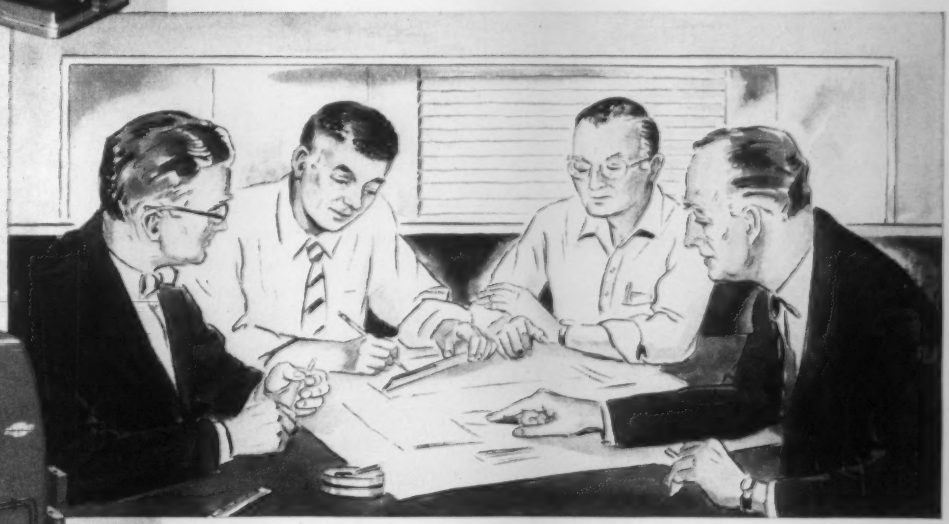
Circle 406 on Inquiry Card

GREENLEE OFFERS

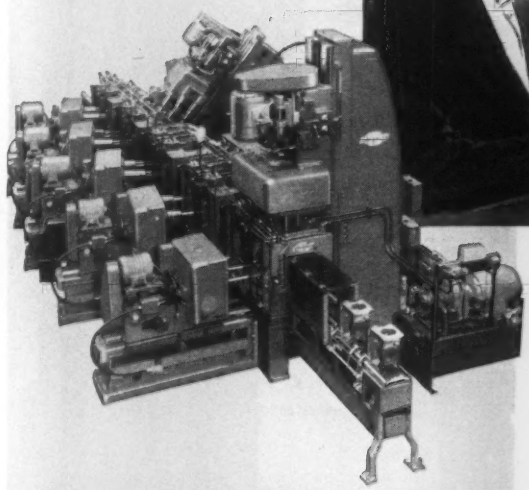
A PROFIT-MAKING INVESTMENT IN HIGH-PRODUCTION MACHINE TOOLS



Greenlee Six-Spindle Automatic Bar Machine.



Greenlee 22-Station Automatic Transfer Machine for machining transmission cases.



Greenlee creative thinking, Greenlee engineering and Greenlee experience combined with that of your own engineers will help you "produce more at lower cost."

Ideas, engineering, experience and facilities of Greenlee Bros. & Co. develop improved methods and machines for greater and greater productivity of future models.

Greenlee's adequate facilities expedite the transition from production ideas to production machines . . . a profit-making investment at work in your plant.

Greenlee 10-Station Automatic Transfer Machine.

GREENLEE STANDARD AND SPECIAL MACHINE TOOLS

- Multiple-Spindle Drilling and Tapping Machines
- Transfer-Type Processing Machines
- Six and Four-Spindle Automatic Bar Machines
- Hydro-Borer Precision Boring Machines

Write for Further Information

GREENLEE

GREENLEE BROS. & CO.
2090 Mason Ave.
Rockford, Illinois

Circle 592 on Inquiry Card

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS

On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify "TEFLON" WIPERS

On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS

On all Hydraulic Cylinders

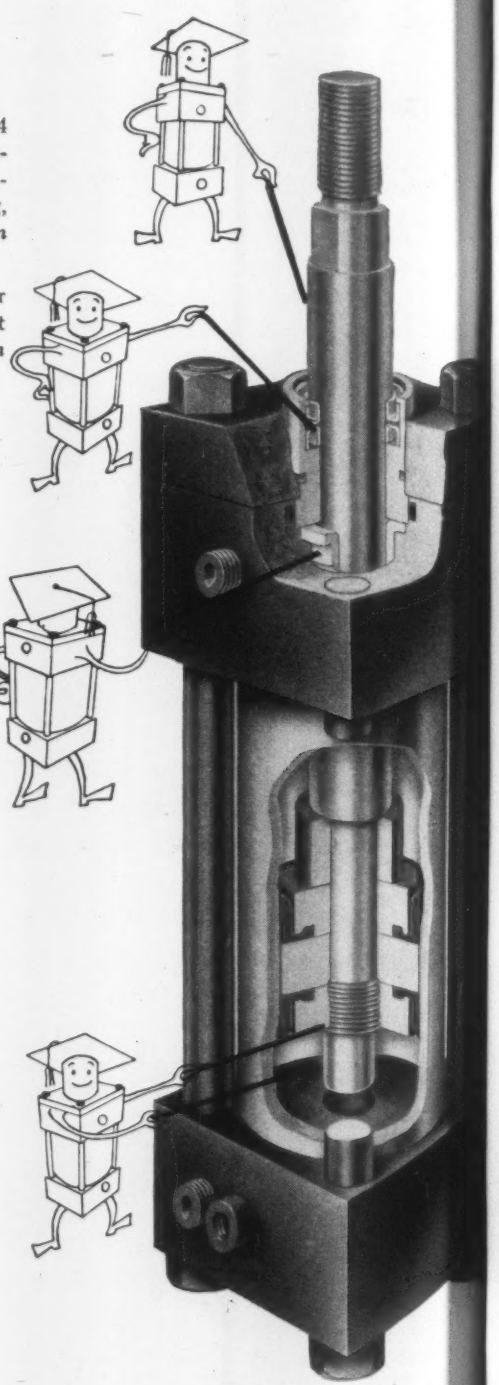
Specify RUST RESISTANT SURFACES

On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

NOTE. On all Miller Hydraulic Piston Seals, Leather Cup Seals are *standard*, Piston Ring Seals are optional *at no extra cost*, and "Teflon" Cup Seals are available *at extra cost*.

Member of the National Fluid Power Association

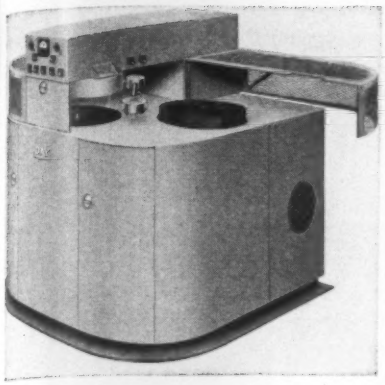
MILLER FLUID POWER DIVISION FLICK-REEDY

2015 N. Hawthorne Ave., Melrose Park,

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUM

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY
BUFFALO • ROCHESTER • MINNEAPOLIS • GRAND RAPIDS • DETROIT • FLINT
FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE
KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE
DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • ATLANTA
TORONTO, CANADA and OTHER AREAS

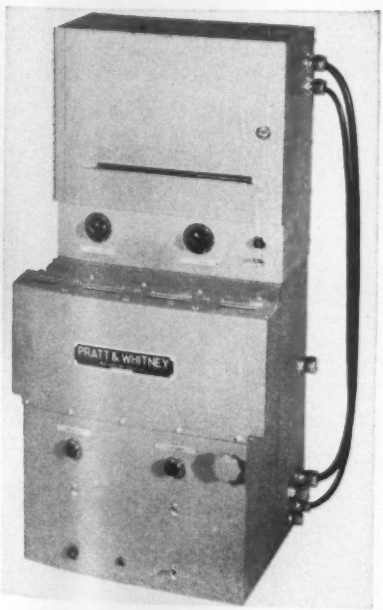


Spin Test Machine

Used for one at a time testing of cut-off saws and grinding wheels at controlled speeds up to 15,000 rpm, spin test machine is called the Autospeeder. The machine loads, spins and unloads automatically. Acceleration and deceleration rate is adjustable.

Specially designed vacuum transfer arms handle porous as well as dense, abrasive cutoff saws up to 20-inch diameter individually, without damage to edges. The machine operates only when safety housings are closed. Controls are grouped on the front panel. **George L. Day Co.,** 1227-1231 Niagara St., Buffalo 13, N. Y.

Circle 407 on Inquiry Card

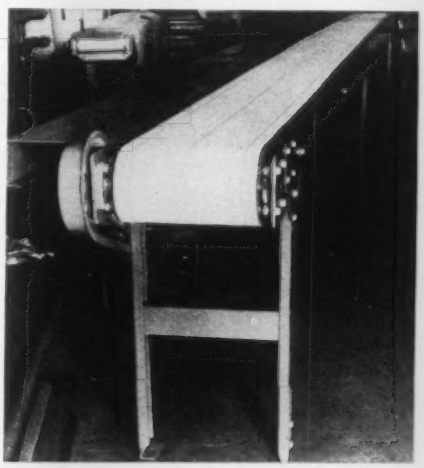


Printing Strip Analyzer

Production analyzing totalizer prints a card record of the on-gage and off-gage footage of rolled strip metal produced by the rolling mill industry. The unit, operating in combination with either contacting or noncontacting continuous strip thickness gages, prints a permanent record in numerical, rather than chart, form.

A typical installation on a finishing mill will accumulate the undersize, on-gage, oversize and total footages in a coil on the last pass through the strip mill. At the end of the pass the operator inserts the standard production work card in the printer, and these footages as well as the time, the date, the coil number, the operator's number, and sets of tolerance zones, are imprinted for the permanent record. During this operation the counters are automatically reset for the next coil. **Pratt & Whitney Co. Inc.,** W. Hartford 1, Conn.

Circle 408 on Inquiry Card

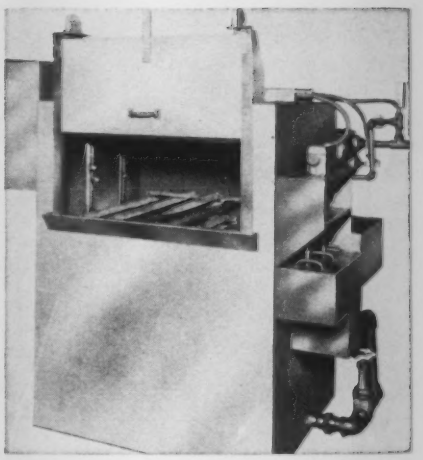


Slide Bed Conveyor

Used in the packaging and assembly of light items such as toys and games, small automotive assemblies, etc., light duty slide bed conveyor can also be utilized as a means of conveying light completed cartons and packages. Unit is available in belt widths of 8 to 12 inches, and 16 inches. Lengths are from 10 to 70 ft, depending on load and speed, in multiples of 10 ft, 0 inches.

Standard elevation is adjustable from 31 to 37 inches. Conveyor is powered by a right angle gear head ¼-hp, single-phase, 60 cycle, 110v motor for fixed belt speeds of 25, 37½ or 50 fpm. **Island Equipment Corp.,** 27-01 Bridge Plaza N., Long Island City 1, N. Y.

Circle 409 on Inquiry Card



Small Parts Washer

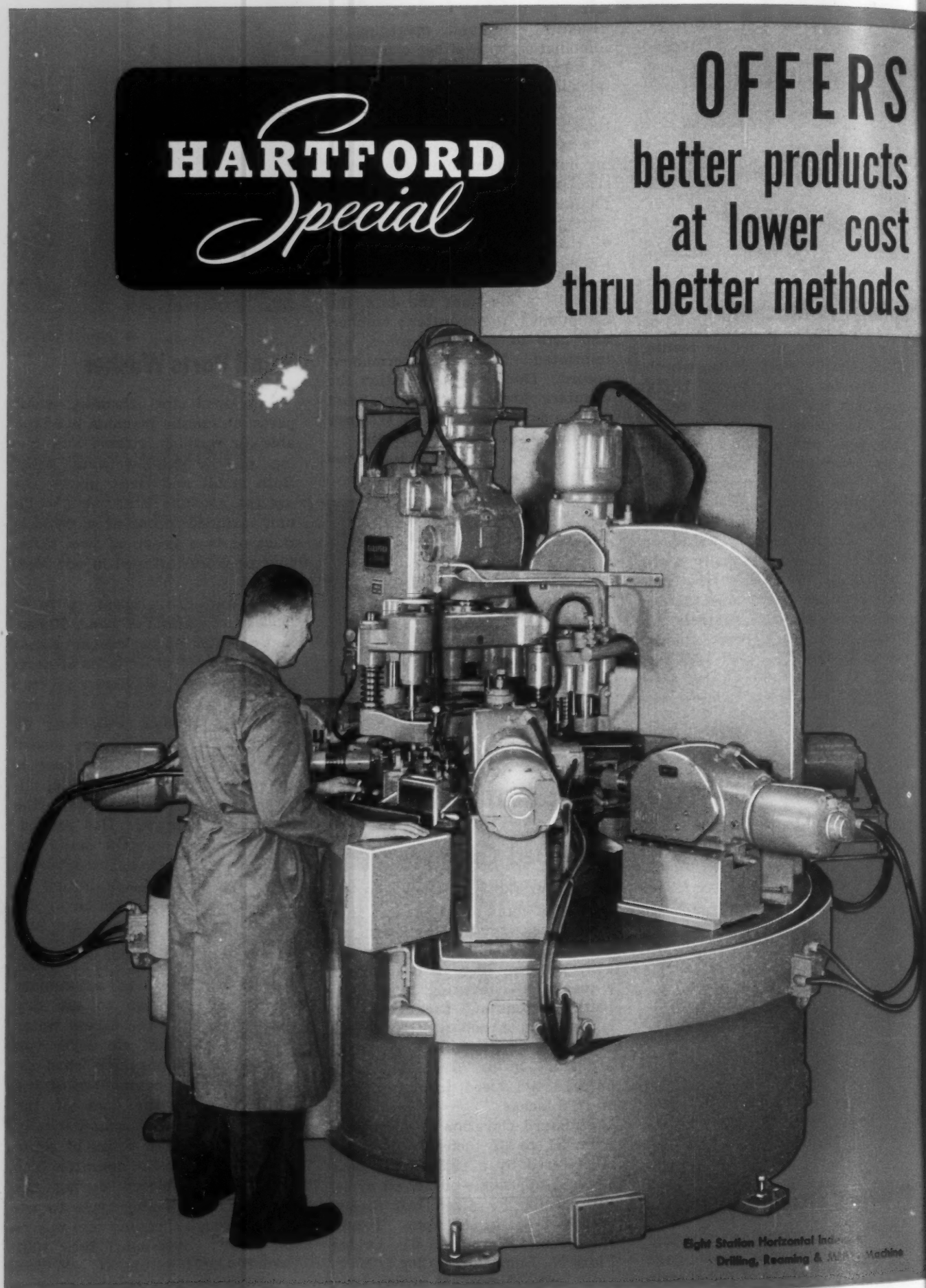
Developed for cleaning small parts, automatic machine is adaptable for washing, rinsing and drying in the metalworking fields. Both small and large plants can use the machine either as a single unit installed in one or more locations or in a group of two, three, four or more installed in one location.

The unit can process up to 40 baskets of parts per hour. Ransomatic small parts washer cleans two baskets or other loads of parts in one cycle. Maximum overall size of each basket is 21½ inches long, 14¾ inches wide and 14 inches high. Baskets are loaded into the cabinet and the door is closed, starting an automatic, adjustable time cleaning cycle in the following sequence: Hot recirculated cleaning solution spray for 30 seconds; hot water rinse spray for 60 seconds and a drain dry for 90 seconds. The machine is designed so that wash, rinse and drain dry periods are widely variable to suit the work. In the rinse operation, the parts accumulate enough latent heat to air dry themselves after the excess water drains off. A hot air dryer can be added to the machine when required. At the completion of the cleaning cycle, the door of the Ransomatic opens automatically and the baskets or racks of parts are unloaded by the operator. The door remains closed during the washing and rinsing cycle to assure thorough cleaning and operator safety. **Ransohoff Inc.,** 1001 Ford Blvd., Hamilton, O.

Circle 410 on Inquiry Card

HARTFORD *Special*

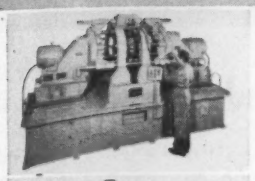
OFFERS
better products at lower cost thru better methods



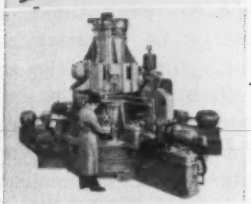
Eight Station Horizontal Indexing Drilling, Reaming & Milling Machine

ONE SOURCE FOR BOTH

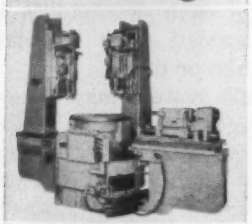
Automatic Production Machines



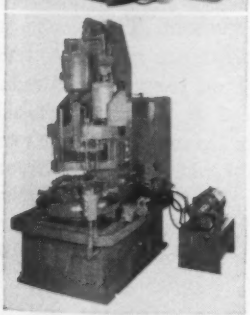
Double End Trunnion Type Machine



Center Column Indexing Type Machine

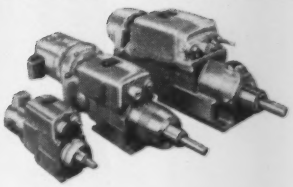


Universal Drilling Machine for jet aircraft components

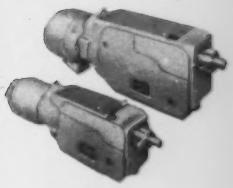


Vertical Single Unit Multiple Spindle Indexing Machine

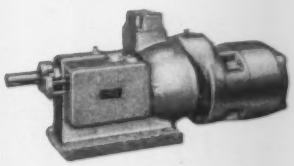
Standard Machine Components



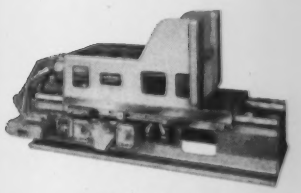
Quill Type Air Hydraulic Drill Units



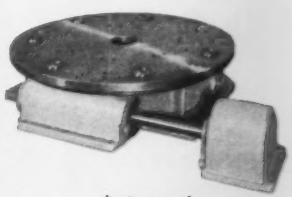
Quill Type Cam Units



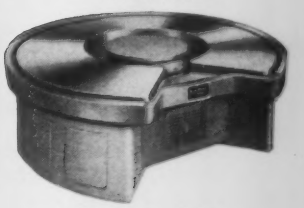
Quill Type Lead Screw Tapping Units



Way Type Hydraulic Feed Units



Automatic Index Tables Horizontal and Vertical



Machine Bases

Designing and building automatic production machines like those illustrated are a "Hartford" specialty. Years of experience have proven that dependable high production and economy can best be brought to the user by means of standard machine components.

Now Hartford Special offers these production tested components to users for machines of their own construction.

Consult Hartford engineers for either—completely tooled machines or components.

HARTFORD Special

MACHINE TOOL DIVISION
THE HARTFORD SPECIAL MACHINERY CO.
28510 HOMESTEAD AVE., HARTFORD 12, CONN.

Hartford also makes automatic Thread Rolling Machines, Special Machinery and the world famous Super-Spacer.

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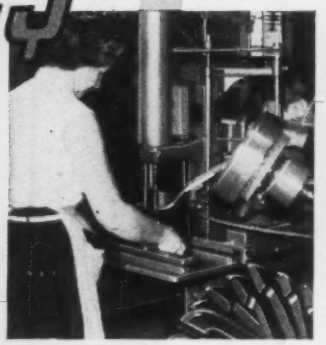
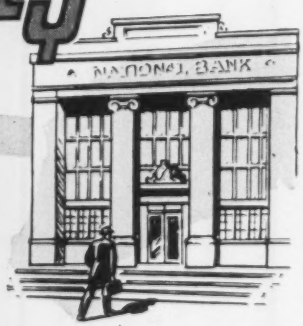
Your PRODUCTION DOLLAR$



will show BIGGER PROFIT DOLLAR$

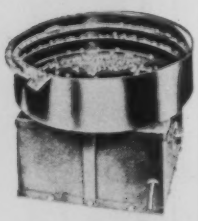


by speeding up your assembling and feeding operations with....

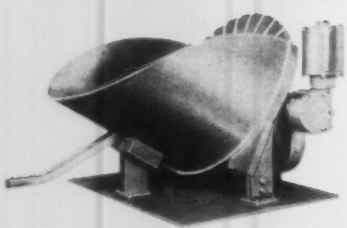
DPS POWER METHODS

● Stepped-up output . . . time saving . . . lower costs . . . Combine them . . . What do you get? A rise in profits. It's today's industrial challenge, and DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS meet it effectively . . . plus the added advantages of uniform, better work, without interruption and the excessive cost of hand methods . . . More than 12,000 successful applications in progressive plants everywhere prove it . . . It lends assurance that we can meet your requirements. Write us . . . Tell us your set-up . . . We'll make recommendations.

5 SCREW-DRIVING MACHINES
Bench and Pedestal types. Pedestal Model A pictured



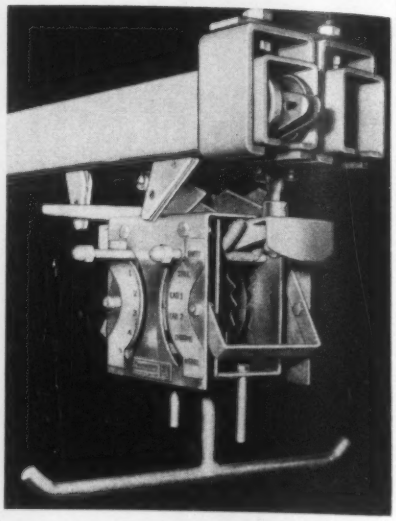
BOWL FEEDER
Vibratory type, to select and feed smaller fragile parts



BARREL FEEDER
with stationary ring cover, for heavy-duty, large production runs

DETROIT POWER SCREWDRIVER CO.
2811 W. FORT ST. DETROIT 16, MICH.

Circle 595 on Inquiry Card

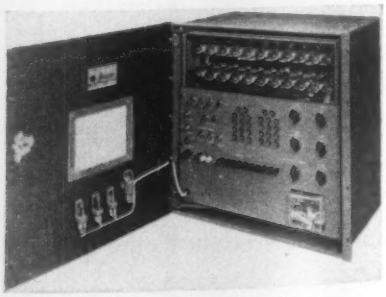


Overhead Dispatching

Designed to provide automatic selective control over the movement of parts to predetermined areas through the production and storage facilities of an entire plant, overhead automatic dispatch system is called the Twin-Trak. Component parts can be automatically supplied to each workstation as they are needed from individual storage banks or lines.

Twin-Trak system may be combined with present R-W Zig-Zag conveyor systems and will integrate many individual conveyors into one factory-wide, automatic conveying system. The system requires a minimum of space; track curves may be formed on a radius as small as 2 ft. Unit is available with either manual or electronic selector controls. **Richards-Wilcox Mfg. Co.**, 174 Third St., Aurora, Ill.

Circle 411 on Inquiry Card



Punched Tape Converter

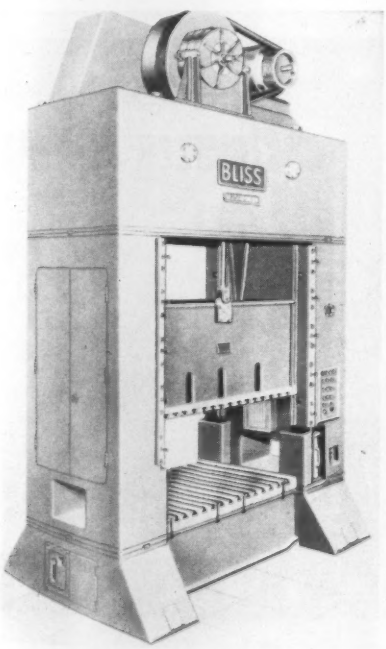
Operating from a punched tape reader, converter is designed to accept data from the output punched paper tape of the Electro-

data Datatron computer. However, it can be modified to operate with any other digital computer furnishing a paper tape output. If a printed listing is desired in addition to the plot, the unit can be operated from a tape-actuated typewriter.

Feature of the new converter is that programming need not be specified on the tape. A number of switches on the converter determine the words and digits to be plotted, so that a particular tape can be run through the converter several times and a different plot obtained each time. While the converter is designed for operation with the Librascope X-Y plotter, it can be modified for use with similar plotters.

Normally, a seven-column paper tape is provided for the converter, although only four columns are actually used. The tape reader operates at 20 characters per second. Maximum plotting speed approaches 40 points per minute. Accuracy of the punched tape converter is ±0.1 per cent. **Librascope Inc.**, Glendale 1, Calif.

Circle 412 on Inquiry Card



Two-Point Presses

Practical for use in job shops as well as in highly automated mass production plants, single-action, eccentric geared two-point presses feature flexibility in basic design which enables press users to have features added to or subtracted from the presses. The design principle involves a quill mounted flywheel and overhung clutch built into a unitized gear case on which the main motor drive is mounted. Except for the main gears, nothing is built into the crown. As a result, the entire drive can be removed from the press and reinstalled, with a minimum of time and effort.

Belts can be replaced without removing anything but the brake bracket. The quill assembly, clutch and all, can be taken out of the gear case by removing six screws. Optional features which can be added to the basic design include: Provision for automatic controls and feeds, inbuilding, various types of automatic lubrication, air and electrical outlets for maintenance tools, die lights, air control mainfolds, etc. **E. W. Bliss Co.**, 1375 Raff Rd., S.W., Canton, O.

Circle 413 on Inquiry Card

EASY TO INSTALL

SIMPLE TO OPERATE

highly sensitive electronic control unit

controls quality during actual processing

CONTINUOUS GAGING OR MOMENTARY GAGING

SENSING ELEMENTS ARE BUILT INTO THE GAGE HEADS
To provide automatic measuring such as gaging and sorting, weighing, pressure control, fatigue testing, inspection, and thickness control.

CONTINUOUS OPERATION

AMAZING SENSITIVITY IS BUILT INTO THESE UNITS
Using standard Industrial Electronic Gage Heads this system of measurement provides four linear full scale displacement ranges from plus or minus .0001 inch to plus or minus .100 inch. Each range is divided into 20 scale divisions on the meter. Dimensional variations of five millionths of an inch are detectable when required.

SHOCK MOUNTED CASE

STANDARD INDUSTRIAL ELECTRON TUBES

CONTROL IS PROVIDED BY MEANS OF 2 POWER RELAYS
They can be adjusted to operate at any desired control point on the meter, and on any one of the 4 sensitivity ranges; on plus or minus tolerances; on 2 successive plus tolerances; or on 2 successive minus tolerances. All initial adjustments are made inside the unit. These units require no other attention during operation—and the panels can be locked to prevent tampering.

INDUSTRIAL electronics, inc.
8060 WHEELER STREET • DETROIT 10, MICHIGAN

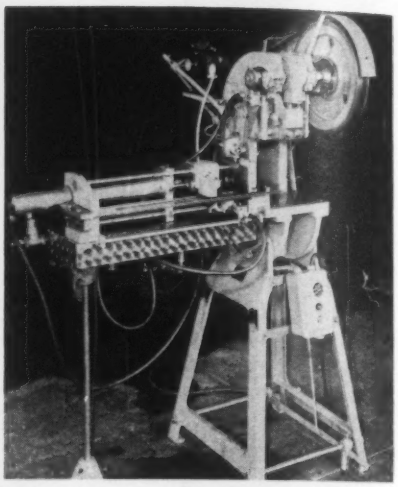
Circle 596 on Inquiry Card

Watch Jewel Sorting

Used to measure and sort tiny watch jewels for selective assembly, automatic gage is designated Model 144 B-58. The tiny jewels used as nonfriction bearings in watches have a precise hole of 0.0008-inch diameter which is the bearing surface. In order to produce accurate timepieces, it is necessary to control the inside diameter of this hole very closely. The sorting gage measures the holes in these jewels and sorts them into four acceptable categories, plus oversize and undersize, at a speed up to 1800 pieces per hour. The four good classifications differ by 0.0001-inch.

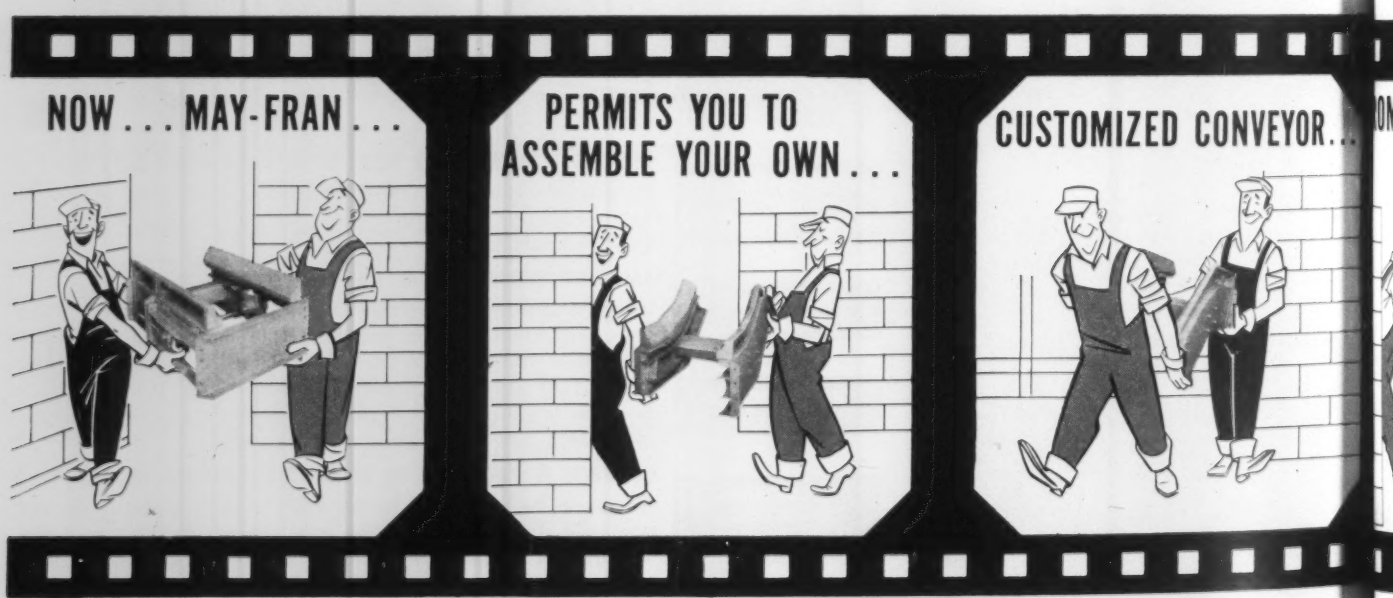
Because an ordinary gaging contact will not fit into the hole, the measurement is made by inserting a tapered, needle-like contact and measuring its depth of penetration. The needle is connected to an electronic gage head by means of a frictionless motion transfer unit, and the depth of its penetration determines the size category of the jewel. In this type of measurement, the taper of the needle is extremely critical and must be held to close tolerances to be sure that the size of the needle does not affect the measurement. When ready for gaging, the jewels are hopper fed to a rotating table and carried to a chute leading to the gaging station. They are fed one at a time into the chute and then into gaging position. With the hole in a vertical position, the needle is inserted to take the measurement. The result is transmitted from the gage head to an electronic classifier which signals a rotating wheel containing the disposal cups so that the correct cup will be under the disposal chute to receive the jewel. **Federal Products Corp.,** 1144 Eddy St., Providence 1, R. I.

Circle 414 on Inquiry Card



Air-Operated Slide Feed

Addition to line is model ASF-12 air-operated slide feed of the open-throat type. With the standard model, feed lengths adjustable up to a maximum of 12 inches can be obtained. Longer feed lengths are possible by using a counting device. With the slide feed, mechanical connections to the press are not required. Width and thickness capacity of the unit are: Up to 15 inches wide by 0.032-inch



Whether you give first consideration to cost . . . or to the overall efficiency of an installation . . . the MAY-FRAN CONVEYOR STANDARDIZATION PROGRAM provides benefits never before possible.

Through STANDARDIZATION, you now can build your own CUSTOMIZED conveyor to meet your own individual needs. The MAY-FRAN components . . . mass produced . . . can be assembled into virtually any type of hinged-steel conveyor for the handling of stampings, formed metal parts, forgings, automotive scrap, chips and turnings.

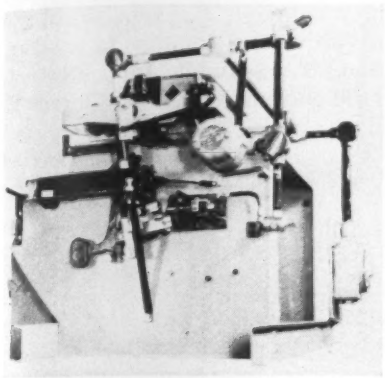
Straight sections . . . concave or convex sections . . . take-up and discharge-end sections can be furnished to meet specific requirements of belt width as well as load bearing and volume capacities.

These pre-fabricated units are available rapidly and at low-cost. You save money many ways with MAY-FRAN standardization because . . . conveyors can be assembled by your own plant personnel . . . conveyors can be modified in any way when production needs change . . . conveyors can be dis-assembled and moved to other plant locations.

thick, up to 12 inches wide by 0.062-inch thick, up to 6 inches wide by 0.125 inches thick.

Illustrated slide feed is mounted on a small press for coil stock. **U.S. Tool Co. Inc.**, Ampere, N. J.

Circle 415 on Inquiry Card

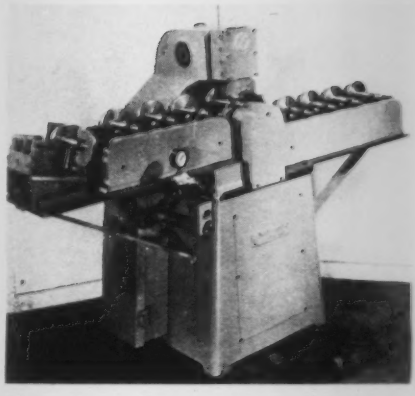


Automatic Scale

An air - operated discharge mechanism plus special motor and electrical components for operation under hazardous gas and vapor conditions are features of automatic scale. Called Model GGG-38, the scale is designed for use in the chemical, plastic, petroleum and similar industries for weighing such products as cellulose acetates, polyethylene, plastic materials and petroleum by-products.

The air-operated discharge for hazardous conditions is used in place of a solenoid-activated discharge normally used on the scale. Standard models of the latter type are used for bulk or bag weighing of dry, ground, granular, dusty and nonfree flowing materials. The scale is available in models weighing up to 250 lb per draft. It features a 1 to 1 weigh beam weighing principle, with sealed test weights in the weight box balanced against an equal mass of material in the weigh hopper. Normal speed range is up to seven 100-lb weighings per minute, with higher speeds possible under optimum conditions. Gravity or power feeds are available, depending on the material handled. Power feeds available include belt, screw or vibrating feed units, all of which are interlocked with the operation of the scale itself. **Richardson Scale Co.**, Van Houten Ave., Clifton, N. J.

Circle 416 on Inquiry Card



Pinion Gear Marker

Designed to mark code numbers on pinion gears as they come off the production line, Model 395 marker is fed by a conveyor chain which carries the pinions under a concave lettering tool, after which they are rolled to a discharge chain from which they are ejected. Production rate is 900 parts per hour.

Machine is driven by a 1 hp motor, which drives the rotating feed spider as well as the feed and discharge chains. A pneumatic cushion is provided in the die holder to accommodate diameter

For complete information, write today for your copy of MF-Bulletin 200

MAY-FRAN ENGINEERING, INC.
1761 Clarkstone Road • Cleveland 12, Ohio

Circle 597 on Inquiry Card

"This Scale Check Chart showed us how to get Better Cost Control"

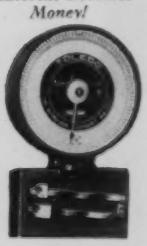
It's New from TOLEDO— send for yours today!

Your scales are a vital element in effective cost and quality control. Errors in weighing go all the way through accounting and affect cost . . . profit . . . or loss! You need to look at *all* your weighing today . . . not as isolated scales, but as a *weighing system.*

Toledo's new Scale Check Chart will show you quickly and accurately how well your scales are serving you, and provide the information you need for truly effective cost control.

This new Check Chart is yours for the asking in a handy kit that contains all you need for an easy, informative appraisal of weighing in your plant. Send for it today. Address Toledo Scale Company, 1415 Telegraph Rd., Toledo 1, Ohio.

On Your Scales... Material Becomes Money!

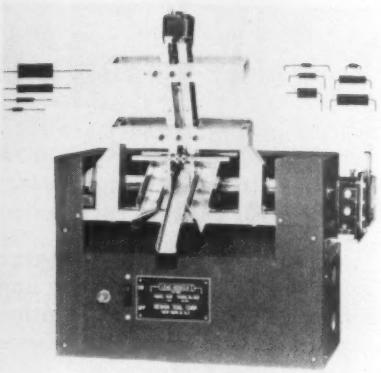


TOLEDO®
HEADQUARTERS FOR SCALES

Circle 598 on Inquiry Card

variations, thus insuring uniform depth of marking on both low and high tolerance limits. Parts are rolled into locator chamber from which they are picked up by chain feed, thus accurately locating the impression. Dies may be made solid for fixed reading, or they may be made up of individual type to provide flexibility in marking. **Geo. T. Schmidt Inc.,** Dept. A, 4100 Ravenswood Ave., Chicago 13, Ill.

Circle 417 on Inquiry Card

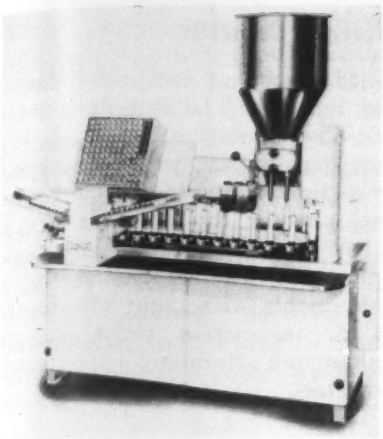


Lead Bender

Capable of preparing 14,000 pigtail components per hour, automatic lead bender is designed to prepare coaxial lead components for insertion in printed board circuits. With this machine, coaxial leads of resistors, capacitors, diodes, coils and similar units are automatically bent to right angles and cut to any length, equal or unequal.

Easy adjustments permit quick set-ups and rapid changes in lead length and distance from angle to body. Thus, short runs do not waste production time. Other adjustments permit the lead bender to accommodate component body sizes up to 2 inches in length and 1 inch in diameter, and individual leads up to 2½ inches long. Depending on desired production speed, components may be fed to a zig-zag chute manually or by optional card, roll or hopper feeds. A constant speed motor, equipped with a speed reduction unit, provides the lead bender with variations in production rate from 0 to a maximum of 14,000 parts per hour. **Design Tool Corp.,** 80 Washington St., New York, N. Y.

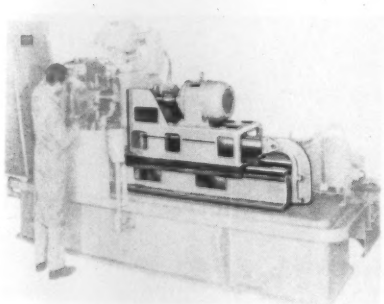
Circle 418 on Inquiry Card



Tube Filler

Production rate of 80 to 100 tubes per minute is achieved by tube filler. New machine features blowing/suction tube cleaning, cap tightening, an air-free filling system, photoelectric tube registration, and various optional coding and crimping methods. Type GAN filler will handle tubes up to 1½-inches in diameter and 7¼-inches long. Special appliance facilitates semiautomatic tube feeding from carton to channels. Tube feed into holders is automatic. Discharge of tubes can be arranged to accommodate any method of cartoning. **Arenco Machine Co. Inc.**, 25 W. 43rd St., New York 36, N. Y.

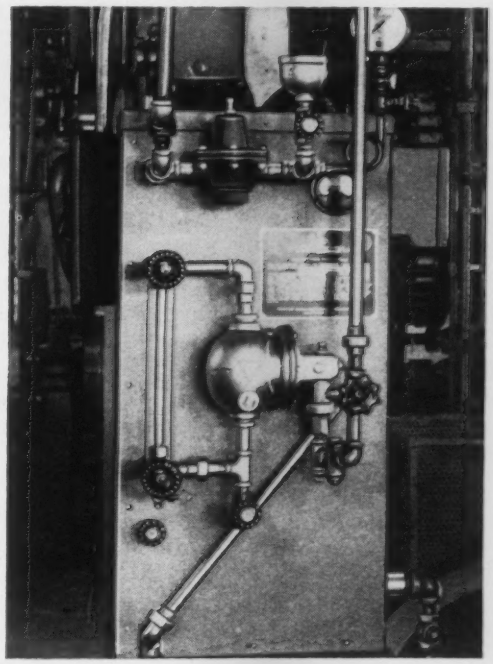
Circle 419 on Inquiry Card



Hydraulic Feeders

Featuring balanced thrust, Series 20-400 and 20-401 horizontal and vertical way type hydraulic feed units are designed to provide thrust above the ways near the tool load. Positive control of rapid traverse, fine feed and depth are possible. Depth will repeat within 0.0005-inch. The flange is designed to simplify mounting and aligning of multiple spindle heads,

Pantex Speedylectric Steam Generator



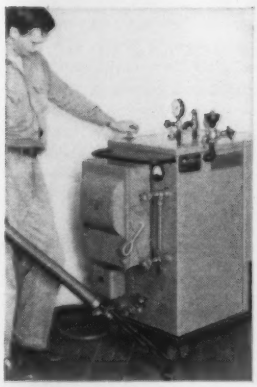
UL Listed
ASME Code

Ideal Steam Source for Pilot, Lab and Test Work

permits precise control of pressure and quality . . . eliminates operator, odor, fumes, fire hazard

Industry uses this "extra" steam boiler in many ways to facilitate production, reduce costs and eliminate fire and explosion hazards. For pilot operations, laboratories and tests the Speedylectric Steam Generator often proves the only answer to steam needs.

It can be installed right in a laboratory, for it requires little space and practically no attention or maintenance. It is silent, odorless, free from fumes and hazards of fire or explosion. It exactly and automatically maintains any desired pressure, and constant quality 98 per cent dry steam. Utilizing the Speedylectric electrode principle, it generates steam electrically, at surprisingly low cost. Capacities from 2 to 60 Bhp; 15 to 500 Psi; for 220, 440, 550 volts AC. USE COUPON to get complete details.



Speedylectric Steam-Jet Cleaner lets one man do the work of five. High pressure jet of dry steam and solvents quickly removes grease and dirt accumulations from machines and equipment *without* flooding floors. No need to stop nearby production or move machines outside. Completely safe and portable.

PANTEX MANUFACTURING CORPORATION
Box 660AI, Pawtucket 9, R. I.

Send me facts and figures on:

☐ Pantex Speedylectric Steam Generator
☐ Pantex Speedylectric Steam-Jet Cleaners

Name and Title .....

Company .....

Address .....

Circle 599 on Inquiry Card

and the 15-inch stroke assures ample tool change clearance.

Feeder develops a maximum thrust of 12,000 lb. Feed rate is infinitely variable from 0 to 24 inches per minute; rapid advance is 8 inches per second, and rapid return is 5 inches per second. **Hartford Special Machinery Co.,** 235 Homestead Ave., Hartford 12, Conn.

Circle 420 on Inquiry Card

Typewriter Encoder

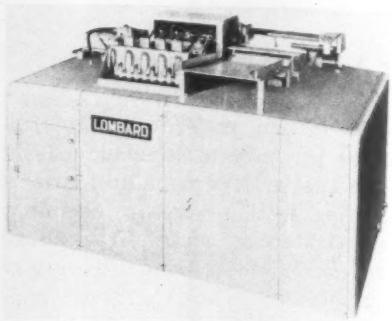
Designed for use with Stanomatic, the electronic unit that senses and translates preprinted coded information from business forms, typewriter encoder can be attached to any standard model electric typewriter and enables a single operator to type numerical information and its dot-code counterpart on the same form at the same time. As a result, faster translation of vital information from source document to Stanomatic to high speed business machine is possible, and a wider variety of source documents may be encoded.

Encoder consists of electrical contacts located beneath the numeral keys of a typewriter and a group of five solenoids mounted in a housing above the type basket. Depression of a numeral key closes a circuit and activates the solenoids. These in turn cause the correct pairings of dot-code hammers to strike the form immediately above the printed digit. A special metallic ink coated carbon paper prints the dot impressions on the form. Selection of the data to be coded by the typewriter encoder is made automatically by the position of the typewriter carriage and by the position of the form within the carriage. **Standard Register Co.,** Dayton 1, O.

Circle 421 on Inquiry Card

Billet Heater

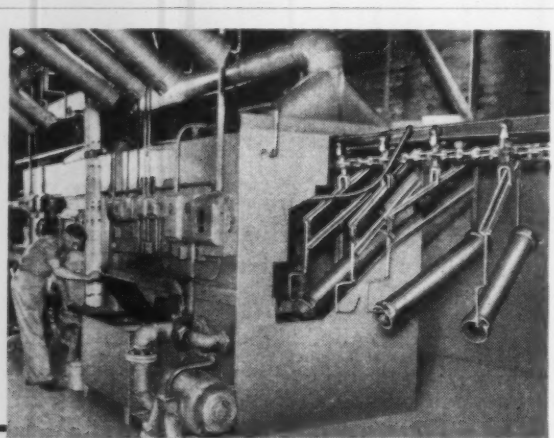
Simplicity of design is a feature of redesigned billet heater. Entire furnace operation is controlled by one pushbutton, which means only two limit switches are used in accomplishing the complete automatic cycling operation. Any degree of taper or uniform heating is obtainable, with slight adjustments. Coil construction is the same for aluminum, titanium, cupro nickel, or steel.



Coils are cooled by water paths that are individually protected. No shutdown or warmup time is necessary with the billet heater. Heat is instantaneously turned *On* or *Off*. **Lombard Corp.,** 639 Wick Ave., Youngstown, O.

Circle 422 on Inquiry Card

A-F JOB-ENGINEERS *INTEGRATED* CONVEYING and PROCESSING SYSTEMS TO MEET *YOUR* PLANT REQUIREMENTS



WHY order a Conveying System from one company— and Cleaning or Processing Machines from another?

INTEGRATED A-F FACILITIES are at your service. Alvey-Ferguson is unique among all manufacturers in being able to offer you a Conveying System completely co-ordinated with your Cleaning and Processing Machines . . . all A-F *Engineered* to your plant's requirements.

BEFORE YOU ORDER, write us. Let us prove how the integration of an A-F *Engineered* Overhead Trolley Conveyor System with A-F *Engineered* Cleaning and Processing Machines will move metal parts and products through your plant at the most efficient pre-determined rate of speed for "quality control" and lowest cost production. Write, without obligation, for new A-F brochures—today.

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Also Pre-Engineered Conveyors—
Wheel, Trolley, Roller, Belt
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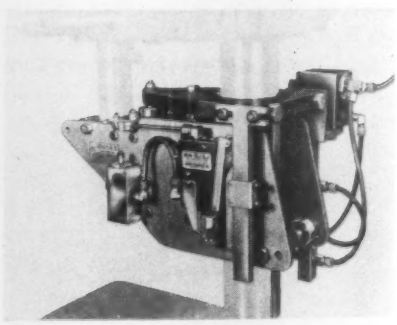
THE ALVEY-FERGUSON CO., 174 Disney St., **CINCINNATI 9, OHIO** and Azusa, California

Circle 600 on Inquiry Card

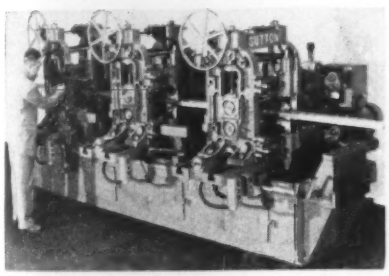


Drill Press Feed

New oil-flow principle which adjusts rate of feed accurately from 2 to 60 inches per minute is employed in air-hydraulic drill press feed. Power is supplied by a double-acting air cylinder and regulated by a small hydraulic cylinder and hydraulic speed control valve. Air cylinder supplies pressure for the downward feed of the drill, and returns it to the starting point after it reaches a preset depth. A system of hydraulic checks maintains a uniform speed, regardless

of soft spots or breakthrough points. The oil check eliminates the usual needle valve and substitutes a spiral oil duct which can be adjusted for speed with great precision. Rate of feed can be accurately determined by the calibrated gage and pointer on the speed control valve, and adjustment can be made while the machine is in operation. The drill press feed operates continuously through a four-way valve and two miniature limit valves. At the bottom of each stroke an adjustable cam trips the lower limit valve, and at the top of each stroke another cam trips the upper limit valve to repeat the cycle. Among features of the system are a floating axial thrust on the drill press quill, and accurate preselection of feed speed. **Mead Specialties Co.,** Dept. DP-46, 4114 N. Knox Ave., Chicago 41, Ill.

Circle 423 on Inquiry Card



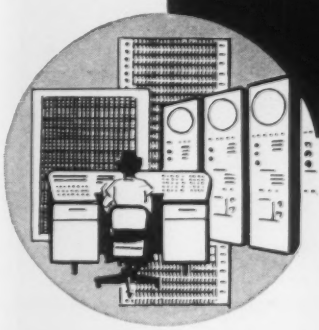
Contour Correction

Developed as effective means of correcting cross-sectional distortions of aluminum extrusions, contour correcting and straightening machine is designed for simple change-over to different extruded shapes. Machine employs multiple rolls of simple design, providing flexibility to correct cross-sectional distortions that occur in the extrusion and heat treatment of complex shapes.

Machine is furnished with one or more contour correcting stands, with provision for additional stands to be added if desired. For simple shapes, a single stand can be used. For more complex shapes, two or more stands are desirable to accomplish multiple corrections in one pass. **Sutton Engineering Co.,** First National Bank Bldg., Pittsburgh 22, Pa.

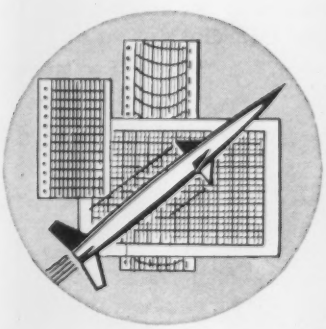
Circle 424 on Inquiry Card

Technical's RECORDING CHART SERVICE has application for you



DIGITAL COMPUTER RECORDS . . .

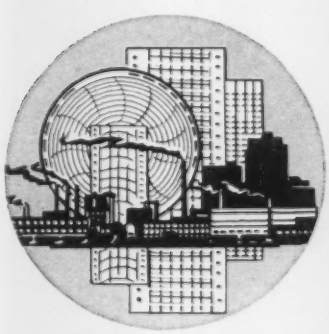
Are you satisfied with your present computer recording forms? Contact **Technical** for help in developing computer or tabulating machine forms best suited for your statistical applications. Information on **Technical's** "know-how" with computer papers sent upon request.



"SPECIAL" RECORDING CHARTS . . .

for new instruments or unusual process needs!

Charts are vital to the **new recording instrument** design. Be sure you contact **Technical** when your project begins and eliminate recording problems at the start! For standard instruments recording under unusual process conditions, **Technical** can supply "Special" charts on heat or electro sensitive and other papers. Send for "Technical Notes" containing helpful new chart specifications.



8000 STANDARD CHARTS . . .

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Chart supply is easy . . . and operating costs are less . . . when you suggest to your purchasing men to buy **all** their chart needs from **Technical. Technical's** acceptance by large and small "Blue Chip" companies is testimony of high chart quality. Automatic order processing and inventory control assure fast service. Write for Catalog 56 and stock list.

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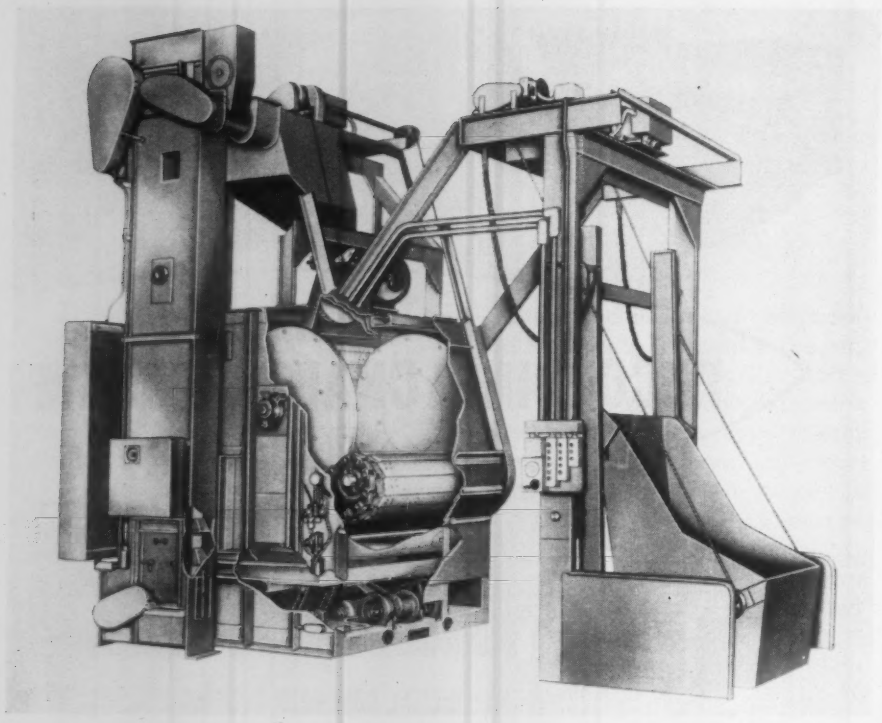
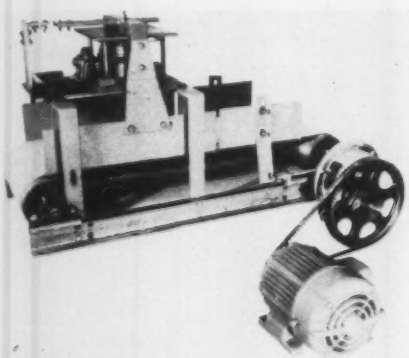


Abrasive Blast Cleaning Machine

Used for cleaning sand, scale, oxides and other contaminants from any work that can withstand a tumbling action, abrasive blast cleaning machine provides reliable performance required for automatic operation. It is readily converted to automation because of its standard power features. The cleaning machine has been successfully operated over long periods without the assistance or observation of an operator. A single pushbutton will actuate the entire sequence from loading to unloading. In those cases where it is desirable to have an operator in attendance, he is free to handle more than one machine or perform other cleaning room tasks. Long-life liners that last from 25 to 50 times as long as standard ones are used to reduce wear and maintenance problems. Blades in the abrasive hurling wheel are made of a material that is also long-lasting. The door is guarded against damage by impact. Sand problems are solved by a high capacity abrasive separator which uses the air separation principle. Power operated door on the cleaning machine, which is called the Super Tumblast, is sealed and rigidly reinforced to keep abrasive inside the machine. The hurling wheel throws 830 lb of abrasive material per minute, making it feasible to employ only one hurling wheel and thus reducing power requirements. **Wheelabrator Corp.,** Mishawaka, Ind.

Circle 425 on Inquiry Card



Weighing Belt Conveyor

Available with control functions which include indicating, recording, controlling, integrating, proportioning and programing, weighing belt conveyor scale uses a pneumatic weight transducer for dependability and the Uni-Force flexure platform for accuracy despite load placement or pile-up. The assembly is available for installation on existing conveyor equipment. Pneumatic weight transducer utilizes a force-balance principle for dependability.

Performance specifications feature 1 part in 2000 repeatability and 1 part in 5000 sensitivity. Unit is unaffected by side thrust forces; springs, knife edges and beams are eliminated. **Weighing & Control Components Inc.,** Box 245, Hatboro, Pa.

Circle 426 on Inquiry Card

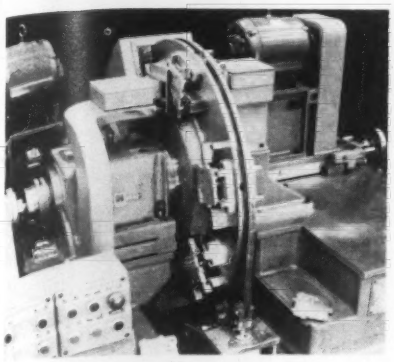
Automatic Assembler

Used for the filling, point insertion, crimping and imprinting of ball pen refills, universal automatic assembly machine is actuated by means of a six-station Geneva movement. The sequence of operations is: (1) insert hopper fed tubes, (2) inspect, (3) inject ink, (4) insert ball assembly by means of hopper fed points (5) imprint (if desired), and (6) eject.

One feature of the machine is all-cam operation. In order to attain smooth performance at 8600 refills per hour, each station is provided with a closely timed work cycle. Ink is injected by means of a barrel cam which incorporates a fine adjustment feature, holding ink quantity to close limits. The ink injection head is a self-contained unit threaded for quick removal for changes to various colors of inks.

Ball point assembly is driven by a barrel cam actuated driver, and micrometer adjustment is incorporated into the machine for setting a positive point position. Safety release mechanism is built into the inking unit to automatically cut out ink injection when the tube hopper is empty. **American Special Machine Co.,** 1401 Webster Ave., Chicago 14, Ill.

Circle 427 on Inquiry Card



Precision Facing

Developed for precision facing of automatic transmission parts and geared to meet high production requirements, Bore-Matic machine provides continuous valve body production at a rate of 270 parts per hour at 75 per cent efficency. A constantly rotating trunnion type fixture moves the parts in a circular path between and at right angles to the two boring heads in opposed positions. Precision facing of two valve bodies clamped on either side of the fixture is done simultaneously. The 12-station fixture rotates at approximately ½ rpm, producing two finished parts every 20 seconds.

Tooling consists of two multiple tool holders each carrying eight single-point carbide facing tools. Raw parts pass through checking stations prior to machining. Limit switches connected to the checking mechanism stop fixture rotation if part is improperly loaded or has excessive stock. A pushbutton reverses fixture rotation for repositioning or removal of defective part. The Bore-Matic removes 0.050 inch stock (aluminum) and provides a finish of 20 micro or better. Conveyor and part handling equipment can adapt the machine to a completely automated setup. **Heald Machine Co.**, Worcester 6, Mass.

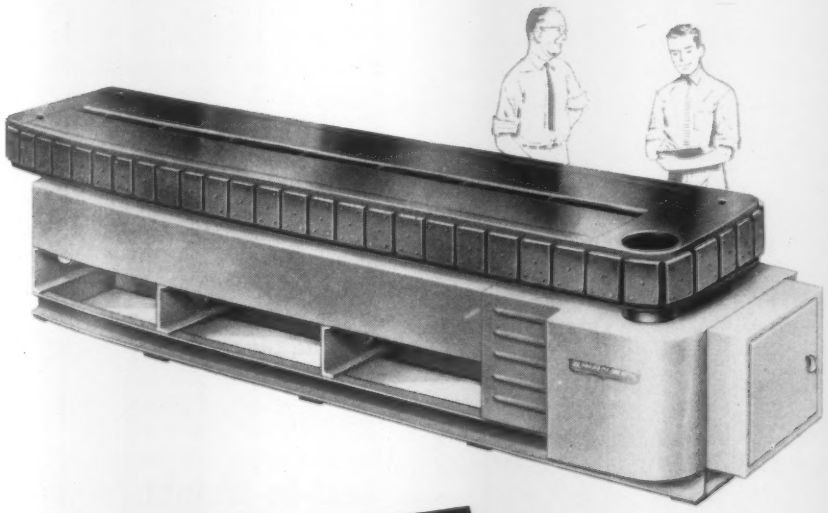
Circle 428 on Inquiry Card

Automatic Packager

Featuring a fast-loading turntable, Model FH 400 packaging machine provides a complete packaging system by sealing up to 6000 items per hour to government specifications in individually

printed envelopes, and prints, seals, packages and cuts off automatically. The machine semiautomatically feeds gaskets, slip-joint nuts, O-rings, bolts, small electronic parts, bearings, gears, valves or grommets from a hopper down a vibratory chute onto a moving strip of heat-sealable foil, paper, etc. An upper strip of sealing material, automatically printed

Plan your Special Purpose Machines
AROUND SWANSON STANDARD INDEXING MACHINE CHASSIS



These standard units offer you a basic chassis for a wide range of special purpose and automatic machines. They give you substantial savings in cost *and eliminate much of your engineering time.*

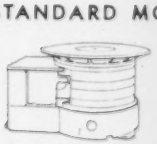
Write for Bulletin 356J. It describes the complete line of Swanson Standard Index Machine Chassis, and shows how they help to reduce the cost of your automation program.

SWANSON TOOL & MACHINE PRODUCTS, INC. • ERIE, PA.

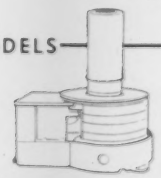
ENGINEERS AND BUILDERS OF AUTOMATIC AND SPECIAL PURPOSE MACHINES SINCE 1919

OVER 200 STANDARD MODELS

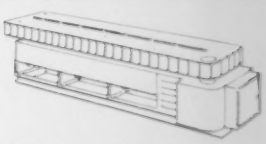
Series B & C Turret Index Models—for medium and light applications.



Series H Turret Index Models—for heavy duty applications.



Series K Turret Index Models—for heavy duty applications with center column tool mounting.



Series L Auto-Tran Straight Line Indexing Chassis—for automatic or semi-automatic assembly and processing operations.

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with specifications or other pertinent data, joins the lower strip at the sealing rolls where the pouch is heat-sealed on four sides and cut. The precise envelopes protect the items against grease, moisture or corrosion, and completely eliminate costly hand sealing.

The FH 400 can accommodate a number of items in a single package because of a pocketed rotary conveyor. An adjustable variable speed drive enables the operator to slow the machine's sealing cycle if necessary while loading multiple items. An advantage of the packager is a shift lever which actuates the transmission to change ratio between the printer and cut-off and sealing rolls, permitting the operator to change bag size without need of additional setup except sleeve changing. **Product Packaging Engineering,** 5747 Marilyn Ave., Culver City, Calif.

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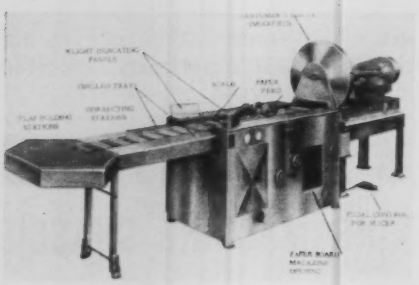

Bacon Processor

Bacon shingling, weighing and packaging is done automatically with machine which is designated EM-129. Unit automatically produces shingled bacon on paperboard, controlling and indicating packaging weight to ⅓ of a bacon slice. The bacon line, used in conjunction with a modified All-bright-Nell slicer, was developed to fulfill a need for a machine to produce shingled ½ and 1-lb packaged bacon more economically and to closer weight tolerances than had previously been possible.

Only six operators are needed to run the machine which consists of an Anco slicer, a shingling conveyor, paperboard feed, indicating scale and stations for weight correction and flap folding. The packages then may be inserted in a standard overwrap machine.

In operation, intermittently sliced bacon falls in groups on a shingling conveyor. These groups then are carried to a point where the waxed card is automatically inserted under each one to form a package. Most efficient operation is in the range of 10 to 24 slices per pound, although other slice variations are possible with the machine. Final steps are weight correction and folding the paperboard. If desired, a cellophane overwrap is added. **Standard-Knapp, Div., Emhart Mfg. Co.,** Portland, Conn.

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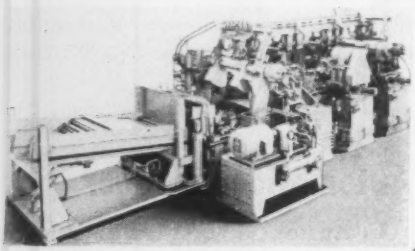

Boring Machine

Automated five-station, in-line transfer type, double-end boring machine features modular construction and an inclined hopper feed mechanism and overhead transfer bar arrangement. The machine flares, faces, chamfers, rough and finish bores both ends of various lengths of tubular steel automotive steering columns at a rate of 414 tubes per hour at 80 per cent efficiency. Both air and hydraulic powered mechanisms operate the electrically controlled machine tool.

The hopper feed has an air-powered mechanism that feeds tubes two at a time to an air-powered oscillating overhead transfer bar arrangement. A rack type unloader removes the parts from the machine. Adjustments are provided for the machining heads and hopper feed to permit the handling of 32, 33 and 34-inch long tubes having diameters of 1½ inches. The three machining stations utilize modular construction, each having identical cast wing bases. A screw conveyor chip trough that carries chips along the length of the machine and deposits them in containers is cast in the machine base. **Expert Automation Machine Co.,** 17144 Mt. Elliott Ave., Detroit 12, Mich.

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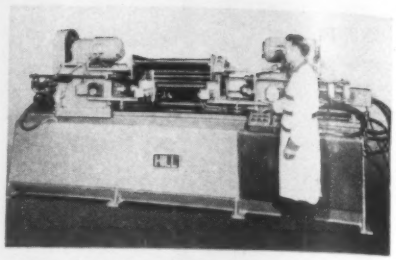

Double-Duty Machine

Automatic, high speed, double-end machines perform either press forming or metal removing operations on both ends of rod or tubular production parts from 1 to 24 ft long, and up to 6 inches in diameter. Machines have hydraulic operated automatic magazine feeds and two hydraulic powered motorized precision heads that can each develop up to 20 tons of thrust force. Production rates range from 300 to 5000 pieces per hour, depending on the part size and operations performed. When the motorized heads are not turning, parts can be fed through the magazine feed in conjunction with a length adjustment feature. Thus the machine can be operated like a forming press that will expand, reduce, flare or bead both ends of the parts simultaneously.

With the motorized heads turning, parts can also be fed with the magazine feed in conjunction with the length adjustment feature. In this arrangement, the machines will burr, chamfer, face, spin, drill, precision bore or ream both ends of the parts simultaneously. These operations can be combined with forming and finishing operations if desired.

Heads are individually controlled and have individual feed and stroke adjustments, enabling different types of operations to be performed on each end of the parts. **Walter P. Hill Inc.,** 22183 Telegraph Rd., Detroit 19, Mich.

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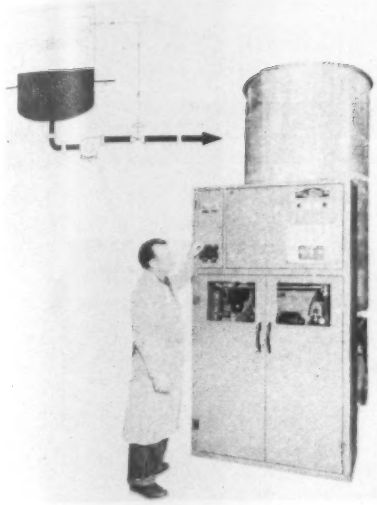
Loss-In-Weight Feeders

Feeding of liquids by weight is possible with line of continuous loss-in-weight feeders, available in both Simplex and Duplex models. Devices feed all types of liquid materials with an accuracy of ±½ per cent, regardless of changes in viscosity, specific gravity or tem-



perature.

Available in feed rates of a few pounds up to 60,000 lb per hour, the feeders will handle clear solutions, suspensions, and viscous, toxic, corrosive or explosive liquids. Feeding mechanisms may be varied to suit the job, and include various types of control valves, gear pumps, and other positive displacement pumps. Feeders are adaptable for discharge into either pressure or vacuum. They can be controlled electronically or pneumatically, or paced by pneumatic, electrical, or line shaft mechanisms.

Because they operate on a deadweight principle, the feeders incorporate a memory device which detects any overfeed or underfeed condition and corrects it automatically. A broad 100 to 1 feed range permits adjustment to meet changes in formulation requirements or increased production loads. **Omega Machine Co., Div., B-I-F Industries Inc.**, 345 Harris Ave., Providence 1, R. I.

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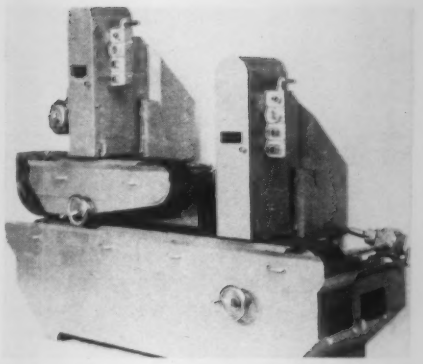
Abrasive Belt Grinder

Used for high-speed precision surfacing both sides of flat parts, two - level conveyor type belt grinder features a dual conveyor arrangement, with turnover hopper device. It is designed to grind both sides of ferrous and nonferrous metals, plastics, glass, ceramics and other materials in a single automatic cycle.

Parts are carried under the upper grinding head on an abrasive conveyor belt, and automatically



turned over in a gravity feed hopper. The lower conveyor belt carries them under the second head for grinding the reverse side. The two-sided belt grinder is adaptable to automatic production lines. Parts can be conveyorized for presentation to the machine's upper conveyor belt and carried to the next operation. The turnover hopper device can be sectionalized for smaller parts.

Speed of conveyor belts with ½ hp conveyor drive is 2 to 25 fpm, with higher speed ranges available for special applications. **Engelberg Huller Co.**, 831 W. Fayette St., Syracuse 4, N. Y.

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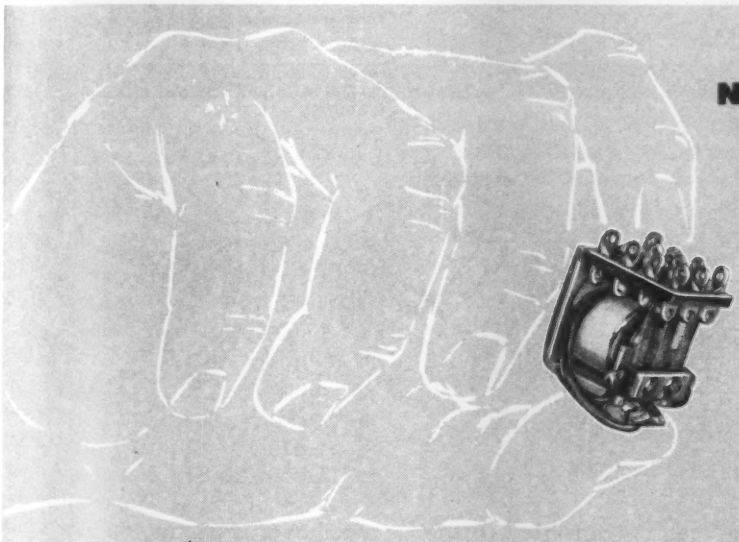

NEW! SUB-MINIATURE 3-POLE
P & B RELAY
FOR MULTIPLE SWITCHING

This new P&B KM series was engineered to meet the pressing demand for miniaturization and multiplicity of action within a single relay. Application possibilities cover a wide field of diverse products, such as:

SMALL BUSINESS MACHINES
ALARM SYSTEMS — INTERCOM SYSTEMS
AUTOMATIC TOYS — REMOTE CONTROLS

Here is only one of the great family of P&B relays . . . one of more than 20,000 design variations. Custom modification of relays, too, is a P&B specialty. Thus you have one *dependable source* for ALL your relay needs!

KM RELAY ABOVE SHOWN ACTUAL SIZE

KM SERIES ENGINEERING DATA

CONTACTS: Max. 3PDT. 3/32" Dia. Silver 2 amps, 115V 60 cy. resistive
VOLTAGE RANGE: Up to 48 V DC nominal
COIL RESISTANCE: Up to 6700 ohms
COIL POWER REQUIREMENT: 1 watt
TEMPERATURE RANGE: —45° C to +55° C
PULL-IN: 75% of nominal voltage
TERMINALS: Solder lugs

P&B STANDARD RELAYS ARE AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield inc.
PRINCETON, INDIANA
Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY

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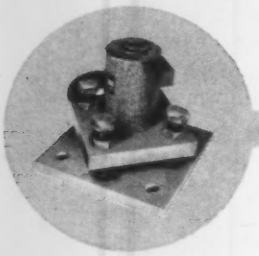
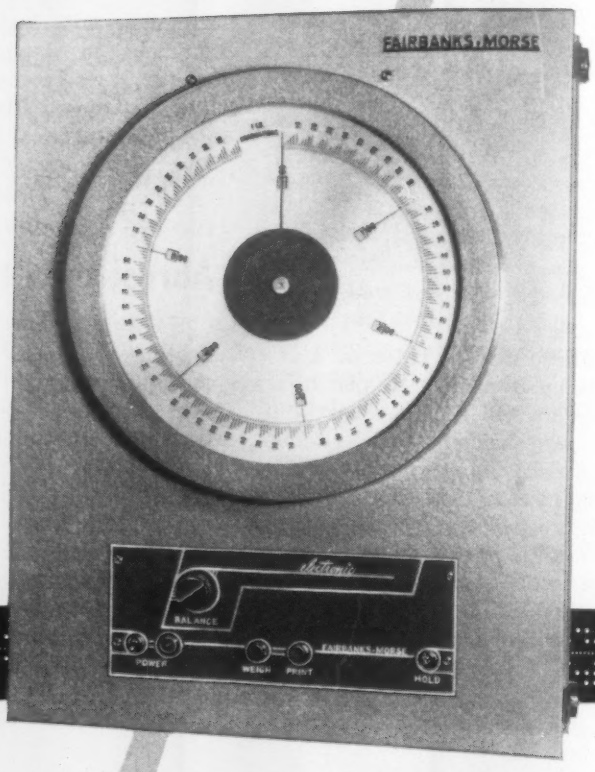
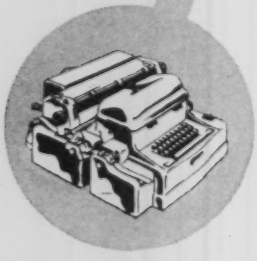
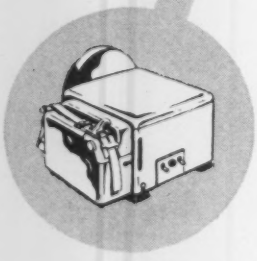
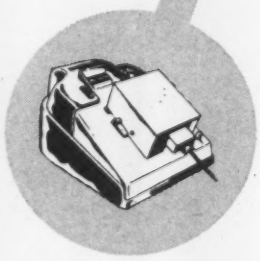


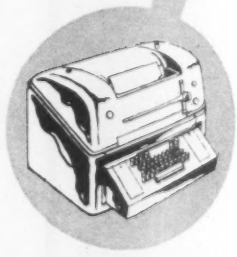
Weigh in the language of accounting machinery











Now it is possible for your scales to "talk" directly to your business machines like automatic typewriters, automatic adders or motorized tape punches. Fairbanks-Morse electronic scales can do this and save you many time-consuming and costly intermediate operations—each with the opportunity for human error.

The weight message from the electronic load cell is translated to the language of business machines by the Fairbanks-Morse Model CDO Readout Instrument. The CDO will convert from decimal to the five channel, seven channel, eight channel or coded decimal codes—whichever system you are using. Send for the new CDO bulletin No. ED-16 today. It will suggest many applications for automatic and remote weighing. Fairbanks, Morse & Co., Dept. A-10, 600 South Michigan Ave., Chicago 5, Illinois.

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SCALES · PUMPS · DIESEL LOCOMOTIVES AND ENGINES · ELECTRICAL MACHINERY · RAIL CARS · HOME WATER SERVICE EQUIPMENT · MOWERS · MAGNETOS

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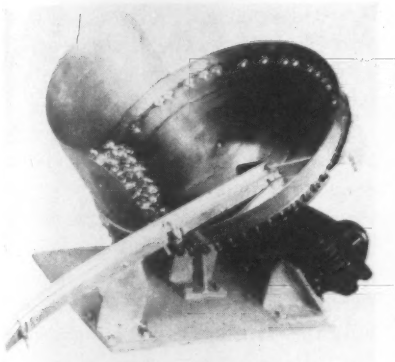
AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 17



Pin Hopper

Used to orient and feed parts that are cup-shaped or parts that have holes or other indentations by which the part can be picked up or oriented, pin hopper provides speeds up to 500 pieces per minute. Most metal or plastic buttons or bottle caps, as well as many other objects, can be oriented and fed in this manner.

Hopper consists of a flat revolving plate inclined at an angle. Around the circumference of the plate are spaced retractable pins. The diameter and location of the pins depend upon the parts to be fed. These pins are cammed upward so as to pick up the part from the mass of parts in the hopper. Parts not picked up by the pins drop back into the mass of parts. An adjustable track is provided, making an angle to the revolving plate and also to the horizontal. As the part approaches the track, the pin is retracted by a camming device, so that the part is released into the track. When the track is full, the parts overflow back into the hopper. The pins are positively cammed so that there is no chance of the pin sticking and jamming the hopper.

Where items like buttons are being fed, a given arrangement will feed a wide variety of sizes. The track is also adjustable to accommodate the full range of sizes that the pins are capable of handling. **U.S. Engineering Co.**, 40-24 22nd St., Long Island City 1, N. Y.

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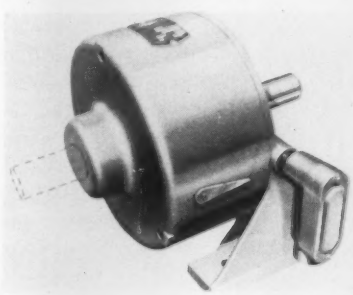
Magnetic Brake

Disk type brake which can be mounted separately from a motor provides the efficient braking advantages of the disk brake to equipment manufacturers who cannot use a direct, end-bell mounted unit. Foot mounted brakes are also available in two types to accommodate different shaft mountings: First has self-contained bearings and shaft for applications where a coupling is used between machine and brake; the second is without a shaft, to permit the extension of the machine's drive directly into the brake.



Other features of the brake include automatic lining-wear adjustment; fast, direct action set and release; manual release with automatic reset; and a doughnut magnet which permits extending the shaft entirely through the brake. Ratings available are 3, 6, 10, 15, and 25 ft-lb continuous duty, and 3, 6, 10, 15, 25 and 35 ft-lb intermittent duty. **Reuland Electric Co.**, Alhambra, Calif.

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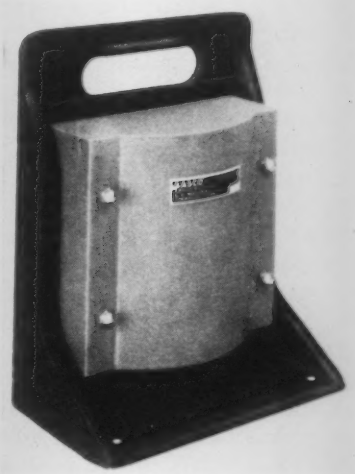

Sheet Steel Separators

Used where continuous sheet steel separation is desired, new separators eliminate marring of sheet edges which results from using ice picks and screw drivers for separating, and the scratching of lithographed or highly polished sheets. A nonmagnetic case fully protects the separators from the demagnetizing influence of metal and metal dust particles.

Permanent magnet units induce a magnetic field in stacked sheet steel when they are placed at the front or side of the stack. The magnetic field created causes the steel sheets to repel each other, with the top sheets fanning out with air space between them. As the top sheets are removed, the sheets below automatically move up, with this action repeating to the bottom of the stack.

Separators are available in 23 models and four sizes, suitable for handling sheet steel from tin can stock up to $\frac{1}{4}$-inch plate, in stacks up to 32 inches high. **E. V. Nielsen Inc.**, 129 Broad St., Stamford, Conn.

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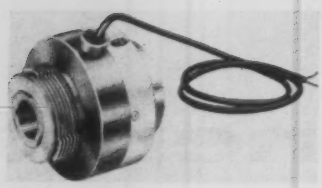

Magnetic Disk Clutch

Used where it is desirable to pick up or slow down a load gradually from a remote station, or as a dead man type of control in conjunction with safety devices, magnetic disk clutch has fully controllable positive action. This feature, combined with compactness and simple wiring, makes the unit suitable for a wide range of automated equipment installations.

The Maxitorq clutch consists essentially of a sealed magnetic coil enclosed in the clutch housing and acting through a sleeve and pressure plate to compress the clutch disks. A design feature is that the electromagnetic actuating mechanism is stationary. Positive pressure is exerted and maintained on the clutch disks entirely by means of the magnetic flux, and there is no mechanical contact between the moving and stationary part. Action of the new clutch in combination with the characteristics of the floating disk design assures instant, positive engagement and disengagement, where this is desired, to a point beyond the rated load carrying capacity of the units. Another feature is that the magnetic flux and, in consequence, the pressure exerted on the clutch disks, can be precisely controlled by varying the voltage. **Carlyle Johnson Machine Co.**, Manchester, Conn.

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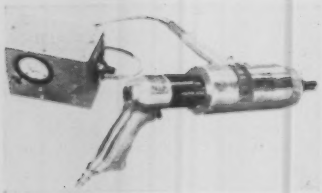

Torque Limiter

Precision torque wrench is a machine driven tool which transmits power through the medium of the patented Magnefluid drive, with a smooth and accurate torque. Simplicity of transmitting torque from one disk to another with no mechanical connection insures reliable operation with long tool life. There are almost no wearing parts in the torque transmitting elements. As each nut is run up and seated in one operation, it is torqued to whatever specification is demanded. Guaranteed repetitive accuracy is 1 inch-lb. A dial setting enables the user to immediately select and use any torque in the tool range. **Swift Tools Inc.**, 3201 S. Prairie Ave., Sioux Falls, S. Dak.

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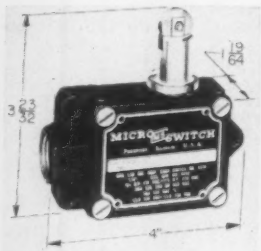

Sealed Switch

Roller plunger, high capacity sealed switch handles inrush currents as high as 75 amp. Switch, designated BAFI-2RQN8, is made oil-tight by integral O-rings around the bushing and plunger, and a ring-type seal between the cover and the housing.

Other features include an actuator that is field adjustable through 360 degrees to allow operation from any direction, a corrosion resistant steel roller, and a heavy plunger bushing. Although the enclosure is compact, ample wiring space and side facing screw terminals allow easy and fast installation. Aluminum enclosure protects the switching unit from physical damage, and also provides a means for mounting and for conduit connection. Switch is available with the actuator positioned either to the right or left.

Operating characteristics are 20 amp, 125, 250 or 460v ac; ½ amp, 125v dc; ½ amp, 2 hp, 230v ac; 10 amp, 125v when controlling tungsten filament lamp loads on ac circuits. Contact arrangement is single-pole, double-throw. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

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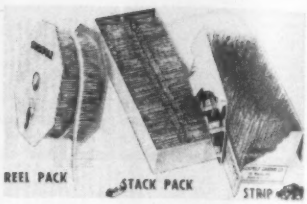

Resistor Packages

New resistor package designs make possible completely automatic handling of the tiny components on a production line basis. Known as Strip Pack, Stack Pack, and Reel Pack, the three types are available for all Stackpole ½, 1 and 2w fixed composition resistors.

The Strip Pack, most versatile of the packaging styles, holds the resistors neatly in a vertical position by small strips of corrugated cardboard into which one end of all resistor leads are inserted. Strips may be withdrawn individually from the pack and rapidly fed into automatic lead cutting and trimming machines, or arranged for hand trimming if desired. Each pack contains 1000 half-watt resistors, 500 one-watt resistors, or 250 two-watt units.

In the Stack Pack, the resistors are interleaved and horizontally stacked in layers in the box so that the units maintain their alignment when the box is dumped into the hoppers of automatic machinery. Stack Packs hold 2000, 1000 or 500 resistors in ½, 1 or 2w sizes, respectively.

The Reel Pack contains 2500 half-watt resistors, 2000 one-watt resistors, or 1000 two-watt resistors. A single strip of ¼-inch plastic tape secured to the resistor bodies is wound around the hub of a hexagonal corrugated reel—allowing the taped resistors to feed into automatic machines in a continuous string. **Electronic Components Div., Stackpole Carbon Co.**, St. Marys, Pa.

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Indicator Lamp Check

Push-to-test oil-tight indicating light lamp is a dual purpose unit. By pressing the lens of the indicator light, the operator transfers the lamp from its normal circuit to a separate built-in test circuit. If the lamp is functioning it will

Behind today's best sellers . . . .

THE CUSTOM ENGINEERING,

THE DEPENDABILITY,

THE ECONOMY OF

Packomatic

AUTOMATIC PACKAGING

(T. M. Reg. U. S. Pat. Off.)

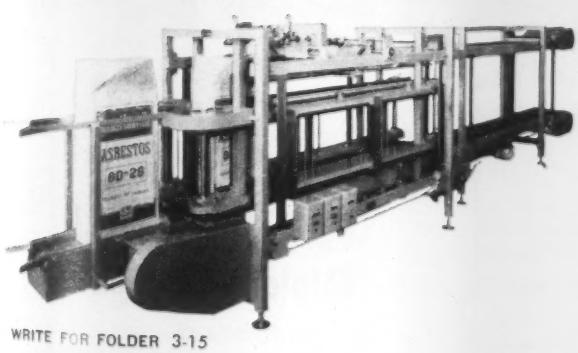
Better packaging means lower production costs and increased volume.

From Quaker Oats Company plants, ten 5-lb. bags of Aunt Jemima flour are shipped to grocers' shelves in paper shipping bales. New Packomatic Bale Sealers automatically fold, glue, position flaps and seal the tough bales securely.

Manufacturers of virtually every bulk or pre-packaged product should consider the safety and economy of the bale for shipping, and the Packomatic Bale Sealer for automatic sealing. Customized to your needs, of course.

But, whatever your package, whatever your budget, there's a particular Packomatic machine for complete automation or for "speed up" of any single operation.

Let a Packomatic representative review your present packaging methods.



WRITE FOR FOLDER 3-15

PACKOMATIC FULLY AUTOMATIC BALE SEALER

Packomatic Bale Sealers, originally designed to handle, glue and seal paper shipping bales up to 100 lbs. weight, can be customized by our engineers for a combination of weights and sizes within these dimensions:

RANGE: *Length:* 9" to 18" in 6" increments
Width: 5" to 9½" in 2" increments
Height: 14" to 40" in 6" increments

SPEED: The regular Bale Sealer is designed for speeds up to 1000 bales per hour.

CONSTRUCTION: This machine is a heavy-duty machine featuring sturdy, square tubular framework, heavy-duty chains, oversize bearings, heavy-duty reduction units and positive safety stop devices.

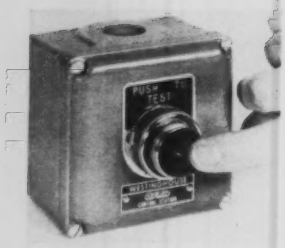
Other PACKOMATIC machines include the Bale Sealer — Case Sealers — Opener-Loaders — Case Imprinters — Telescoping Volumetric Filler — Packer-Gluers. Units available, semi-automatic or fully-automatic depending on your needs.

Over 50 years' experience in Customized Packaging Equipment

J. L. FERGUSON COMPANY Joliet, Illinois

New York, Chicago, Cleveland, Boston, Tampa, Baltimore, Portland, Denver, Los Angeles, San Francisco, Seattle, New Orleans, Louisville, Kansas City and all principal Canadian cities.

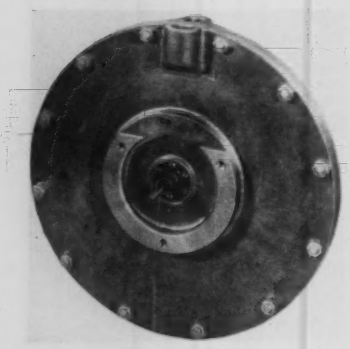
Circle 605 on Inquiry Card



light normally to indicate that trouble shooting is in order. If it fails to light, replacement of the lamp can be easily done by maintenance personnel.

Push-to-test indicating lights are of the transformer type and are available 110, 220 and 440v applications. Open cover or panel mounted units are available. **Standard Control Div., Westinghouse Electric Co.,** Beaver, Pa.

Circle 442 on Inquiry Card

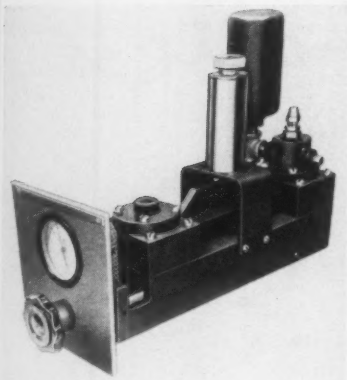


Measuring Device

Low-pressure diaphragm manometer is a measuring element which has been designed to actuate Taylor indicating, recording or controlling instruments. It is suitable for measurement of vacuum, pressure or differential pressure where ranges do not exceed 4 inches of water, static pressure is no more than 5 psig, and where toxic-gas vacuum or differential pressures are not measured. Manometer consists of a large 302 stainless steel convoluted diaphragm in an aluminum housing built to give rugged service without excessive weight. It is well suited to the measurement of low pressure, differential pressure and flow in air and gas lines where the operating range is −0.5 to +0.5 inch or 0 to 1 inch water gage.

Equipped with a thicker diaphragm, the instrument is also available for applications where ranges from 0 to 3 inches and 0 to 4 inches of water are met. All forms have overrange protection to 30 inches of water gage. Static pressure is limited to 5 psi. Simplified zero adjustment is accessible within the case of the measuring instrument. Manometer is fully compensated for changes of 50F in ambient temperature. **Taylor Instrument Cos.,** 95 Ames St., Rochester 1, N. Y.

Circle 443 on Inquiry Card



Ratio Relay

Designed for the pneumatic control field, Model 3-15 ratio relay produces a true linear change in pneumatic output signal when using suppressed ranges such as 3 to 15 psi. It fulfills a need by giving an operator a device for adjusting the ratio between input and output signals in control systems such as fuel to air in combustion processes, ratio of gases in gas mixing and proportional feeding of chemicals.

The relay features true ratioing around 3 psig input and output bias pressures using a convenient handwheel for changing the ratio. Precision fulcrum drive assures exact ratio adjustment. The relay is compatible with any pneumatic signal system having a range of pressures between 0 and 20 psi. Another feature of the relay is a simple method of altering the suppressed scale setting when and if desired. Although primarily designed for use with 3 to 15 psig signals, a simple adjustment permits changing the minimum input and output bias values to any point between 0 and 6 psig. Maximum input and output signals may be at any value up to 20 psig. **Hagan Corp.,** 323 Fourth Ave., Pittsburgh 22, Pa.

Circle 444 on Inquiry Card

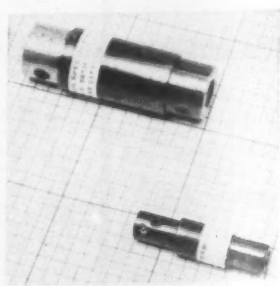
Load Cycle Counter

Adaptable for accurate proximity or impact counting, telemetering load cycle counter counts only work or operations actually performed. It differentiates between idling, dry run and load cycle and counts only the load cycle. Device can also be used as a warning and/or counting instrument for material change characteristics, dull tools, etc.

Counter is actuated by sensing the current flow to electrically driven machines, such as presses, broaches, drills and mills, or in tempering, welding and other electrically powered operations. The telemetering feature permits simultaneous counting at the machine and at a remote location such as a production control center.

Device is available with a six-digit counter capable of being reset, with speeds up to 1000 counts per minute. Power consumption is 25 w. **Ram Meter Inc.,** 1100 Hilton Rd., Ferndale, Detroit 20, Mich.

Circle 445 on Inquiry Card

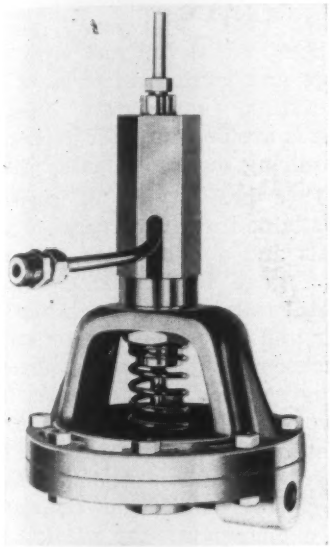


Miniature Clutches

Nonreversing, single-revolution, overrunning and indexing operations are available in two clutch models — S and O. Model S is used for single revolution and

start-stop applications — wherever a load is to be controlled intermittently from a continuously rotating point. The latter model is designed for all overrunning, backstopping, nonreversing and indexing operations. Model S miniature clutch transmits up to 10 inch-lb of torque without slippage, and may be operated at speeds up to 1800 rpm. Subminiature Model O transmits up to 15 inch-oz of torque at speeds up to 1800 rpm. **Precision Specialties,** 1342 E. 58th St., Kansas City, Mo.

Circle 446 on Inquiry Card

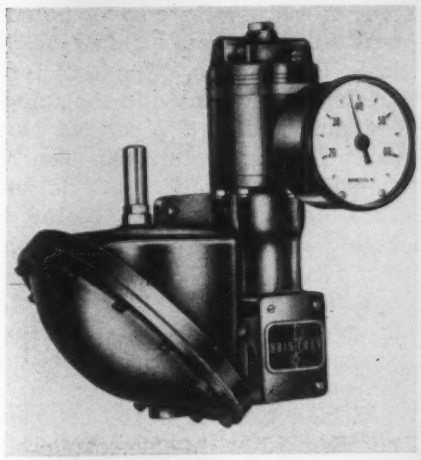


Flow Valve

Used for slurry service where the solids in suspension tend to plug conventional type control valves, new device is called the Sphincter Valve. It is designed for handling erosive process flows or flows containing gritty solids which cannot tolerate pockets, but will accept neoprene or natural rubber. The valve produces minimum turbulence in the flow through the valve.

Only parts exposed to wear in the Sphincter Valve are a rubber seat and an O-ring. The seat is compressed along its axis to produce throttling action and tight closure. Tubing sizes of ¼ and ⅜-inch outside diameter are available. Manual or air operators are available for quick interchange when desired. **George W. Dahl Co. Inc.,** 430 High St., Bristol, R. I.

Circle 447 on Inquiry Card

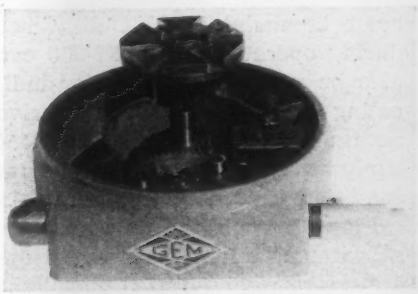


Pressure Transmitter

Used in pneumatic transmission instrument systems, absolute pressure transmitter will measure pressures in ranges as low as 0 to 5 mm Hg absolute, and transmit the measurement as a pneumatic signal to an automatic controller or receiver.

Called the Metagraphic Absolute Pressure Transmitter, the device is offered to handle pressure ranges from 0 to 5 mm Hg to 0 to 760 mm Hg. It transmits a universal 3 to 15 psi pneumatic signal, and can be used with any standard pneumatic receiver or automatic controller. **Bristol Co.,** Waterbury 20, Conn.

Circle 448 on Inquiry Card

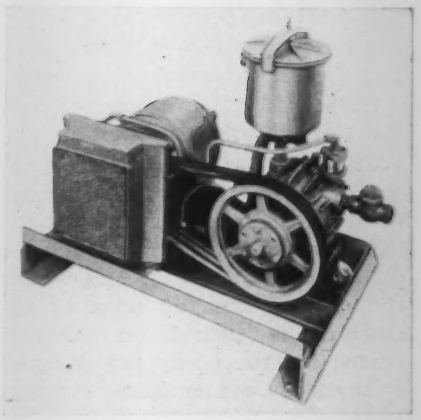


Dial Index Table

Designed to automate assembly and machining operations, GEM-17 dial index table is used for drilling, tapping, riveting, spinning, staking, knurling, chamfering, welding and screw driving machines, gaging devices, and other operations. The index table is used successfully by automotive manufacturers, parts suppliers and other high volume manufacturers. The table, which has true Geneva motion, will index to ±0.001-inch on a 13-inch diameter work circle. The workpiece is positioned smoothly and quickly in as little as ½-second. Table will take a 1000-lb work load on the standard 17-inch diameter plate. Its anvil, which is solid through the table, has a capacity of 30 tons when properly supported. An air motor, solenoid valve and limit switch are included with the table.

Indexing time is 2/3-second with 1150 rpm motor. The locking bolt in the Geneva slot is cammed both in and out. **Gray Equipment Co.,** 13600 Ford Rd., Dearborn, Mich.

Circle 449 on Inquiry Card

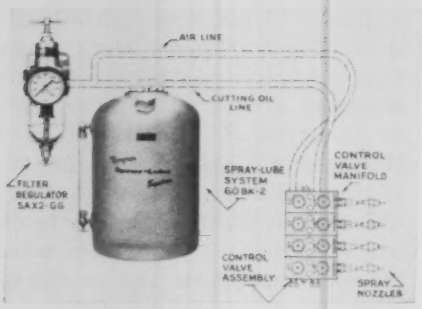


High Vacuum Pumps

Radiator cooled lubricating system is used on two high-vacuum pumps producing vacuums of 24 to 29.9 inches Hg, with capacities of 15 to 40.8 cfm, for continuous operation at average temperatures of 140F. Elimination of watercooling removes the need for water pipes, eliminates wasteful use of water and leakage problems, and the necessity of placing pump near water supply.

Lower operating temperature is maintained by circulating precooled SAE 30 lubricating oil through the pump. Constant recirculation of the oil through the radiator maintains a constant low operating temperature that gives maximum lubricating effect, prevents carbonization of oil, increases pump life and reduces maintenance. Pump speeds up to 800 rpm are made possible to provide greater air capacity in a smaller size pump. **Leiman Bros. Inc.,** 102 Christie St., Newark 5, N. J.

Circle 450 on Inquiry Card



Spraying Cutting Oils

Flow of air and cutting oil is accurately controlled with new spraying system. Spray-Lube applies a uniform and high quality spray of cutting oil directly upon the close interfaces of the curled chip, or from any other angle that will best reach the critical lubrication points. The spray of coolant exposes a large fluid surface area and thus absorbs more heat.

Oil spray is produced within the nozzle itself, by means of a tube within a tube, resulting in a spray that is consistently uniform in quality. The spray is delivered to the cutting area as soon as the machine is turned on. Control valves for the spray are designed so that they can be closely mounted in manifold for multipoint application of the Spray-Lube system. They can be adjusted to regulate the flow of both air and liquid to deliver the right spray for any metal cutting operation.

An average size unit occupies a space only 7 by 14 by 20 inches with a 2-gal liquid reservoir; for most operations, a spray uses 4 to 12 fl oz of cutting oil per hour. **C. A. Norgren Co.,** 3499 S. Elati St., Englewood, Colo.

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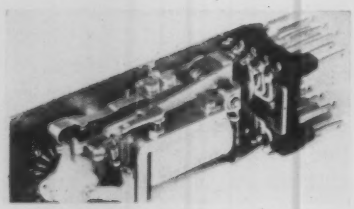
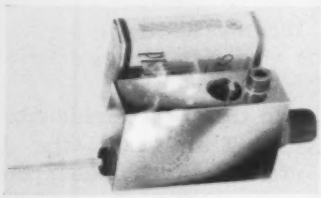


Stepping Relay

Characterized by its long life and high stepping speed and consisting of a 12-point arc assembly, rotor assembly and driving motor, stepping relay has a stepping speed of 80 steps per second with stepping pulses of a 50/50 make-break ratio. Impulse type driving motor is used in the standard unit with a 48v dc, 244 ohm coil. Driving motors can also be supplied for 24v dc, 110v dc and 120v dc, or 110v ac. Motor is fitted with a self-interrupter contact for driving the motor from a continuously applied voltage. An interrupter cam is fitted to stop the motor when the rotor is in the normal position.

Molded bakelite contact assembly is used with one row of 12 terminals. Relay has a life in excess of ten million revolutions. **International Standard Trading Corp.,** 22 Thames St., New York 6, N. Y.

Circle 452 on Inquiry Card



Flow Indicator

Suitable for installation on a variety of small, low capacity circulating systems such as vent, lube and cooling lines, Model FI-900 flow indicator will find application on the cooling systems of electronic equipment where flow must be maintained at all times during operation. The FI-900 can also be used as a bypass or indicating differential relief valve across filter systems or component equipment to indicate a bypass condition caused by clogging.

Flow through the unit actuates a switch that can be used to operate a remotely located pilot light or other warning device, or with suitable relays, to operate preventive interlocks. The instrument operates on a pressure differential of less than ½-psi. Standard models are offered for ⅜-inch pipe and tube connections.

The flow indicator has no moving linkages, flexing parts or gaskets. Operation on all standard models can be set at any desired point from 5 to 50-gph by means of an external adjustment. **Gems Co.,** Newington, Conn.

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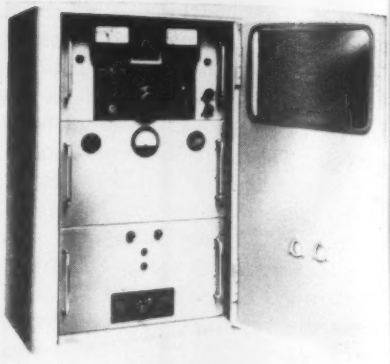
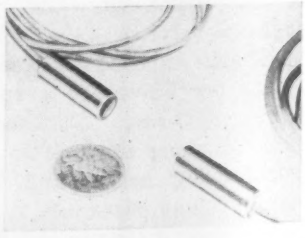


Thickness Gages

Used for the continuous measurement and production control of sheet paper and board, plastics, rubber, metal foil and strip, coatings and laminates, series of Beta radiation, noncontact thickness gages are designed for applications requiring superior quality control.

Five basic types of gages are available for a wide range of materials and applications: Transmission gage for paper, paperboard, metal foils and strip, plastics, rubber and other sheet materials; the backscatter gage to measure coatings such as paint, lacquer, adhesives, rubber and other moving materials which are accessible from only one side; the differential gage for measuring coatings on thin materials; the multiple head transmission gage for greater widths of the same materials; and the transverse profile portable gage which measures thickness across the entire width of a sheet. Range of weights or thicknesses that can be measured covers all normal manufacturing needs. **Nuclear Corp. of America Inc.,** Suite 4219, Empire State Bldg., New York 1, N. Y.

Circle 454 on Inquiry Card



Photoelectric Control

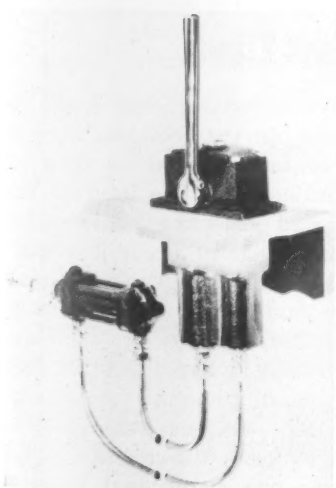
Developed to fill the need for miniaturization of both a light sen-

sitive detector and its associated light source, new device is called the Micro-Eye electronic controller. The detector is a semiconductor device which is extremely sensitive to light. Changes in the amount of light falling on the detector initiate an electrical response in the control circuit which may be used to operate most electrically controlled devices.

Response of the light detector to light is in the order of 5 milliseconds, giving an overall relay time of approximately 0.02 seconds when going from dark to light. On decreasing light, the detector exhibits a slight delay action which is more pronounced at the higher light intensities. In some control applications this is desirable as it will allow for normal passage of objects without actuating the unit.

An additional adjustable time delay may be included to give delays up to approximately 5 seconds. When set for minimum time and a low light intensity the unit can operate a counter at about 450 counts per minute with the standard relay. Power requirement is 110 to 125v, 60 cycle ac. **Industrial Design & Engineering Associates Inc.**, Bethlehem, Pa.

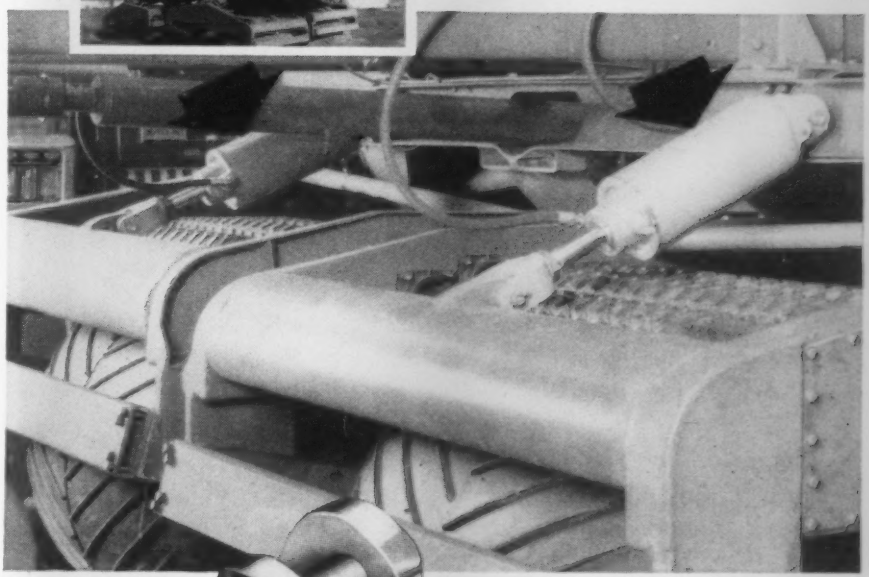
Circle 455 on Inquiry Card



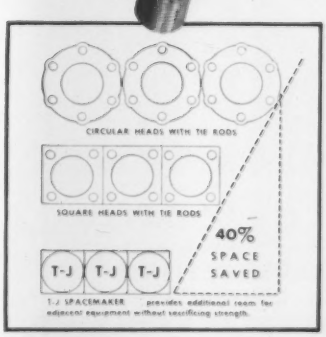
Hydraulic Positioning

Self-contained, manual-hydraulic positioning devices are called Hydra-Trols. Units feature smooth, infinite control and sensitive feel; positive stroke in both directions; no lag or lost motion; and automatic compensation for leaks and

Arctic Cargo Carrier Depends On T-J Spacemaker CYLINDERS



ALL MODELS... OFF SHELF DELIVERY


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
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T-J SPACEMAKER ... provides additional room for adjacent equipment without sacrificing strength.

Saves 40% Space No Tie Rods... Greater Strength

Differential axle loading through T-J Spacemaker Air Cylinders forms a controlled walking beam in this Tera-cruiser, designed and produced for the Army Ordnance Corps by the Four Wheel Drive Co., Clintonville, Wis.

Weight of cylinders was important factor in choosing T-J Spacemakers, which reduce weight while providing same displacement and extra high safety factor. Fast delivery and space-saving features also favored T-J. Exclusive with T-J are new Super Cushion Flexible Seals for Air (to 200 P.S.I.) . . . and New Self-Aligning Master Cushion for Oil (to 750 P.S.I.). Hard chrome plated bodies and piston rods are standard, at no extra cost. Wide range of styles, capacities . . . 64,000 combinations *off the shelf!* Write for bulletin SM-155-3. The Tomkins-Johnson Co., Jackson, Mich.

MEETS WITH ALL JIC RECOMMENDATIONS

T-J TOMKINS-JOHNSON
DIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

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IMMEDIATE DELIVERY

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- **100% EXPANSION OF FACILITIES**
  Carter is geared to give service. We have increased our plant capacity to handle orders on an IMMEDIATE DELIVERY basis.
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  Carter cylinders are designed for fast production and immediate off-shelf assembly from standard parts.
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  Carter produces around the clock. Your order for cylinders is in process *in a matter of minutes* after we receive it.
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  Carter maintains complete spare parts and experienced engineers in 40 different locations throughout the United States, Canada, and Mexico.
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  Call in your order any time of the day or night. Carter will take your order and begin processing it right away.

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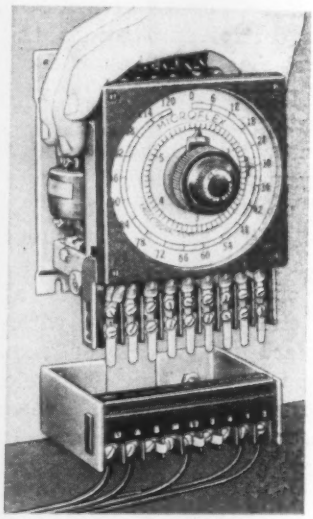
Circle 607 on Inquiry Card

other changes in fluid volume at both ends of the stroke.

Hydra-Trols are used in hydraulic valves on presses, tube bending machines, roll mills, etc.; for the control of throttle, mixture and spark on production and experimental engine test stands; in marine engine controls; in slitting machines, winch control and air and gas butterfly valve control. Remote control units do not depend on either outside power or spring return. **Trimount Instrument Co.**, 3119 W. Lake St., Chicago 12, Ill.

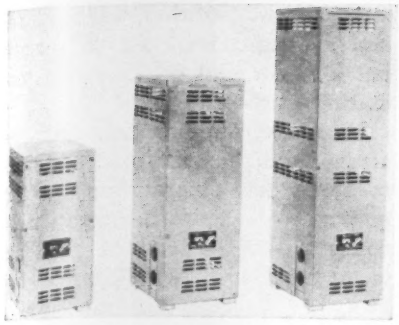
Circle 456 on Inquiry Card



Reset Timer

Synchronous motor driven reset timing device trips its three sets of contacts closed or open after an adjustable time interval. Starting and resetting of HA4 Series Microflex reset timer is electrically controlled. Timer's threaded axle and pinion allows accuracies to ±1/60-second on a 20-second dial. More than 100 timer operating combinations are available. Devices are available for time ranges from 0.3-second to 120 hr. Timer has a terminal panel with the terminals in one row, making the device easily adapted to plug-in connection. Plug-in kits are available for this purpose. In addition, the terminal panel may be rotated in a matter of seconds to provide rear connection without rewiring of any kind. **Eagle Signal Corp.**, Moline, Ill.

Circle 457 on Inquiry Card

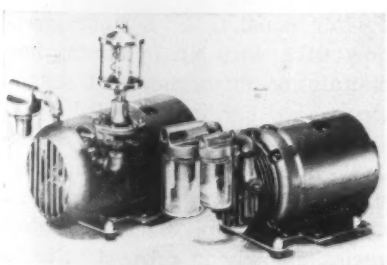


Variable Transformers

Used for any application involving the control of heat, light, speed, power and voltage where it is desirable to operate a unit remotely or by instrumentation, new devices are called Adjust-A-Volt variable transformers. Applications for motorized units include the controlling of speed with the speed of the line by remote control means, automatically raising or lowering voltage for various tests by means of instruments controlling the variable transformer, and applications in aircraft and electronics industries.

Transformers are available in single or up to six ganged assemblies. Operation is from 0.35 to 28 kva at 115 or 230 v. All units are equipped with clockwise and counterclockwise limit switches. Four standard speeds of 6, 13, 26 and 45 seconds for full range travel are available on each model. **Standard Electrical Products Co.**, 2240 E. Third St., Dayton 3, O.

Circle 458 on Inquiry Card



Rotary Air Pumps

Suitable as original equipment on automatic machines, industrial instruments and controls, printing and photoengraving equipment, and as portable laboratory air sources, three rotary air pumps are of integral motor design. Reduction in weight is one of the features of new pumps. Units have the rotor mounted directly on the shaft of a G.E. motor.

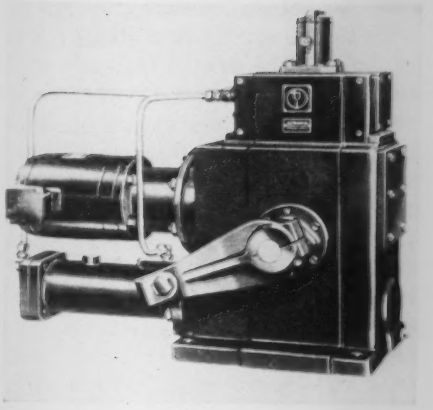
Model 0211 with 1/6-hp motor weighs 22 lb and has a resilient, rubber cradled motor mount for quieter, more vibration-free operation. It delivers up to 1.3 cfm of free air at 1750 rpm, with vacuum to 27 inches or pressure to 25 psi. Model 0321 delivers up to 2.2 cfm with ¼-hp motor. Vacuum is produced to 28 inches, pressure to 25 psi. Model 0521 delivers larger air volume to 3.8 cfm with 1/3-hp motor. Bulletin VP-356-8 describes the units. **Gast Mfg. Corp.**, Benton Harbor, Mich.

Circle 459 on Inquiry Card

Solenoid Valve

Primarily designed for ac applications (both pressure and vacuum), two-way, direct solenoid controlled valve features in-line construction for easy inspection and servicing. All control parts can be removed in one small assembly by loosening one hexagonal nut. Normally closed valve is available in standard pipe sizes from ½ through 2 inches. Having only two moving parts, it assures positive, high-speed action with short plunger travel. Noncorrosive throughout, the valve can be controlled by a relay or limit switch. It can be mounted in any position and operated continuously without harm to the valve or the solenoid. **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, O.

Circle 460 on Inquiry Card

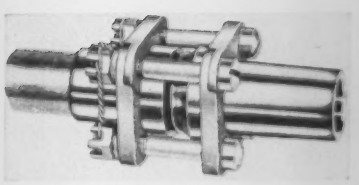


Hydraulic Regulator

Well suited for relief and reducing valve applications involving lever or butterfly valves, self-contained hydraulic regulator is also employed for the control of fluid flows and as a remote valve positioner. Called the Powerpack Regulator, the unit can be used on liquid level applications, feed water pumps, steam pressure reducing stations for pressure control, flow control, antisurge governor for blower installations and many other places where it is particularly effective because of the high power corrective action which it develops.

Power is greatly increased near the closed position of the valve and gives the extra power needed to shut valves tight or break sticking valves loose. **Askania Regulator Co.**, 240 E. Ontario St., Chicago 11, Ill.

Circle 461 on Inquiry Card



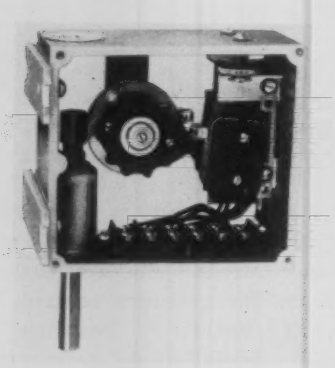
Tubing Connector

Effective connector for joining tubing to tubing, or tubing to various kinds of equipment is called the Split-Flange Connector. Design of the device has been used on aircraft and ordnance equipment to keep hydraulic tubing connections leakproof and safe, regardless of shock or vibration. Connections are unaffected by twist-

ing and turning of the tubing.

In the simplest connection, (that of joining a piece of flared end tubing to a part with a tapered shoulder) the connector consists of a pair of split flanges, one sleeve with a shoulder, and four bolts, nuts and lock washers. The split flanges are locked and are then tightened by the four bolts and nuts. For applications where extreme vibration may be encountered, a wire lock may be used with the lock washers. **Barco Mfg. Co.**, Dept. J-22, 501 N. Hough St., Barrington, Ill.

Circle 462 on Inquiry Card



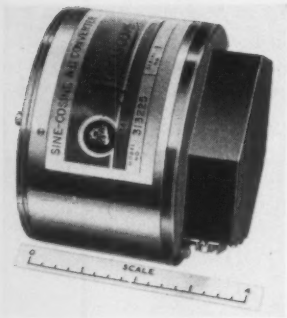
Rotating Limit Switch

Used to limit the travel of electrically operated doors, conveyors, hoists and similar mechanisms, rotating limit switches also have application as pilot controls to operate solenoids of magnetic reversing starters or contactors. Switch has heavy duty pilot ratings to 480 v and incorporates two single-pole, double-throw, snap action contact assemblies. Other features of the switch include: General purpose cast aluminum housing with removable cover plate on each side of the switch to provide complete accessibility for wiring; oil-lite bearings on the input shaft plus heavy duty worm and cam gears to insure long mechanical life; and easily accessible adjustments for cams and snap switches. **Furnas Electric Co.**, 1128 W. McKee St., Batavia, Ill.

Circle 463 on Inquiry Card

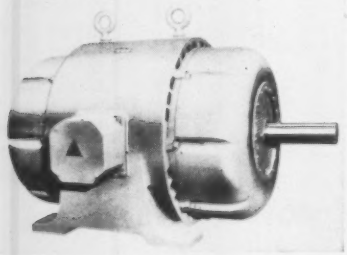
Sine-Cosine Converter

Eight-bit sine-cosine analog to digital converter consists of two disk type commutators with pick-off brushes. Double-brush V-scan system is used to avoid ambiguity. Input shaft is scaled at 360 degrees per revolution full scale input. No intermediate gearing is necessary. Coding is in continuous serial binary form in increments of two to eight for values of the functions from zero to one. A ninth bit is included to enable the encoding of the value one.



Instrument is coded such that each quadrant is divided into 257 parts, each part representing equal values of the functions. Both sine and cosine values are simultaneously available. **Librascope Inc.**, Glendale 1, Calif.

Circle 464 on Inquiry Card

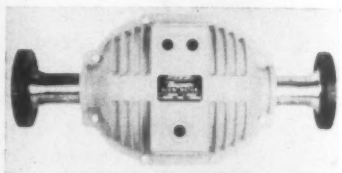


Fan Cooled Motor

Featuring a double-end ventilation system, totally enclosed, fan-cooled motor operates in the size range from 50 to 200 hp. New design employs two external cooling fans, one at each end, which draw cool, fresh air directly across each bearing, then drive it the length of the motor through large cooling tunnels cast in the walls of the main frame. The fans are designed to direct the air onto the bearing housing with considerable force, scrubbing away heat and maintaining uniformly cool bearing temperatures. The large, non-clogging tunnels, being integral with the frame walls, provide efficient heat transfer to the air stream. In addition, each tunnel has a longitudinal fin to smooth out air flow and provide extra radiating surface.

Each fan handles only half the air volume required, and since air passages are generous in size, the new motor is quiet in operation. A deflector at the end of each air passage directs the discharge air away from the cool air intake. Bearings are open type with provision for regreasing and pressure relief without removing any part of the motor, should such servicing be necessary. **Delco Products Div., General Motors Corp.**, Dayton 1, O.

Circle 465 on Inquiry Card

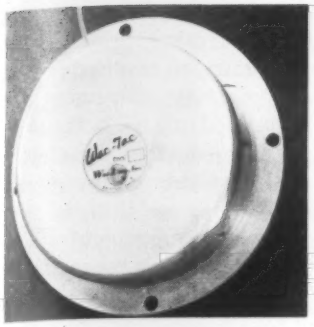


Flow Meter

Particularly applicable in the pulp, paper and chemical industries, magnetic flow meter is available for 1-inch flow lines. The smaller meter offers all the advantages of the larger instruments (2 inches and up)—overall accuracy of ± 1 per cent of full scale throughout the entire scale, no restriction of flow, linear flow readings, and performance unaffected by pressure, viscosity, density or changes in conductivity of the flowing liquid.

Unit consists of a nonmagnetic flow tube with an insulating liner containing flush mounted metallic electrodes and surrounded by an ac electromagnet. When a conductive liquid passes through the tube, an alternating voltage is set up between the electrodes which varies linearly in proportion to the rate of flow. Lead wires from the electrodes transmit this voltage output to a Foxboro recorder, producing a chart record in appropriate units of flow. The device permits accurate metering of the highly corrosive chlorine dioxide solutions used in the bleaching of paper pulp. **Foxboro Co.**, Foxboro, Mass.

Circle 466 on Inquiry Card



Speed Indicators

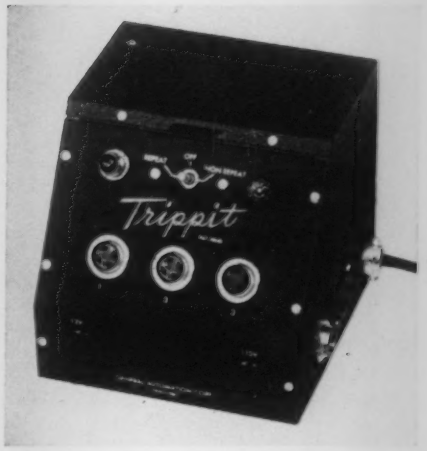
Designed to fill a need for closely coupled speed indicators to be used on integral horsepower motors and automatic machinery, Model 5 tachometer is used on rotating machinery. The pancake design provides a minimum of protrusion beyond the machine to which it is attached. It also provides a sturdy mounting means. Damage from handling and from collisions with other equipment is thereby minimized.

Device delivers an ac voltage whose frequency and magnitude are linear with speed, making the design useful in controls sensitive to either frequency or voltage. The generator sinusoidal voltage may be as high as 25v per 100 rpm and the frequency is 30 cycles per second per 100 rpm. No slip rings, brushes or contacts are used. Model 5 is available for mounting within the frame of the motor or machine, or for external attachment. **WacLine Inc.,** 35 S. St. Clair St., Dayton 2, O.

Circle 467 on Inquiry Card

Power Press Control

Called the Trippit, new electric combination master control brings efficiency to the operation of power presses, shears and brakes. For hand fed and secondary operations, the piece part trips the press automatically. The press will not operate until the piece is properly and accurately nested. A second stroke cannot be obtained until the piece is removed and another blank inserted. Gaging is automatic, rejects are eliminated, and the point of operation can be guarded completely. With power shears, pedals become unnecessary. Shearing starts automatically as soon as the material is



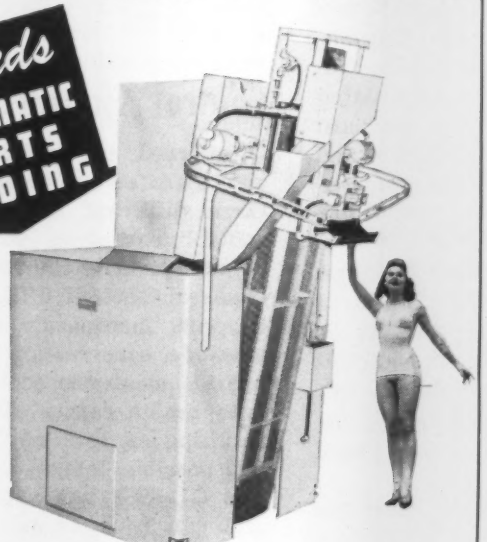
squared against the stops.

On fully automatic setups, when the master control panel is set to repeat, the press will stop automatically when jamming occurs or the end of the strip or coil is reached. There is also a provision for automatic shutoff of the press after a preset count. Provision is made for photoelectric operation and safety, press overload protection and operation of auxiliary equipment such as slide feeds. **General Automation Corp.,** 65 S. Broadway, Yonkers, N. Y.

Circle 468 on Inquiry Card

WORLD'S LARGEST HOPPER

Speeds AUTOMATIC PARTS FEEDING



Think of it! With a *45 Cu. Ft. Hopper* FEEDALL Model 2500B elevates parts and feeds them thru multiple chutes to assembly lines or production machines. Huge hopper saves storage space — prevents floor cluttering.

Work Range: Rolling Parts 5″ in dia.; 3/16″ to 1½″ long.
Sliding Parts 3/16″ to 2″ in dia.; 6″ long.

Complete Specifications on request. In writing advise purposes for which automatic feeds are required.

FEEDALL INCORPORATED WILLOUGHBY, OHIO

Circle 608 on Inquiry Card

FREE

Engineer's Fact File

on EBERT'S UL All-Purpose

Mercury Plunger Relays

For all loads up to 60 AMPS or 5 HP.

Send for FREE FACT FILE and 30 day test details

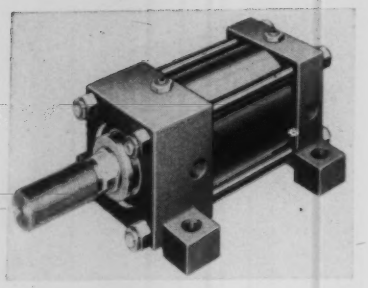
★ 35 Millisecond Fast Action! ★ Hermetically Sealed!
★ Installs in one minute! ★ No maintenance required!
★ No pitting! No sticking! No corrosion! ★ No Sparks!

Solves your relay problems once and for all

EBERT ELECTRONICS CORP.

212-39 Jamaica Ave., Queens Village 28, N. Y.

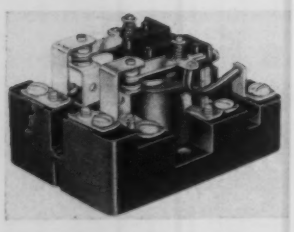
Circle 609 on Inquiry Card



Hydraulic Cylinders

Used for pressures to 2000 psi, line of hydraulic cylinders is identified as Logan Supermatic. Seven bore sizes, from 1½ to 6 inches, are available; maximum stroke is 72 inches. Cylinders are provided in five mounting styles: Foot, trunnion, centerline, flange, pivot and manifold with interchanging covers to permit multiple mounting combinations. Piston rods are of highly polished steel to assure minimum friction and maximum packing life—available in either standard or heavy duty size in both male and female. Ports are unobstructed and can be relocated to any 90-degree position by rotating cylinder covers. Cushioning is available for either or both cylinder ends as specified. **Logansport Machine Co. Inc.**, Logansport, Ind.

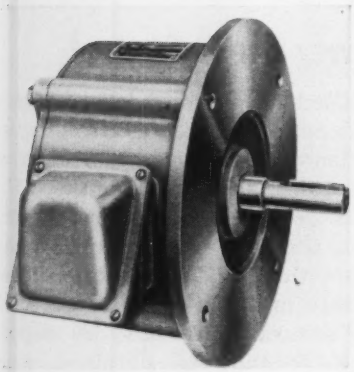
Circle 469 on Inquiry Card



Power Relay

Motor starting, heater loads and heavy industry control systems are among applications of 25-amp heavy duty power relay. Unit is compactly designed to meet space limitations yet its electrical characteristics are equivalent to bulkier, heavier power controls. In addition to switching heavy current or high voltage loads, relay incorporates a patented interchangeable coil feature. By removing two accessible screws, the complete coil assembly can be removed and replaced quickly by a coil of the same or different value ranging from 6 to 230v ac. Contacts are heavy duty type and are rated at 25 amp continuous duty, at 230v ac, with 75 per cent power factor load. Standard unit is double-pole, double-throw. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill.

Circle 470 on Inquiry Card

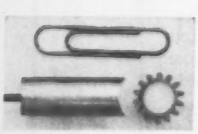


Flat Type Motor

Developed for use in the machine tool and equipment industries for operating turret lathes, punch presses, milling machines, pumps, oil burners, exhaust systems and similar applications where there is a minimum of space, motor features flat type construction. Providing maximum horsepower with minimum size, the motor, in totally enclosed fan cooled, or totally enclosed nonventilated design, weighs less than standard motors. Unit is of standard radial design, constructed like conventional squirrel cage motors. Rotor weight of the motor is evenly supported between two ball bearings.

Operating at 208, 220 to 240, or 550 v, two or three-phase at 60 cycles, continuous or intermittent duty, motors are available in ratings ranging from 1/3 to 7½ hp. **Diehl Mfg. Co.**, Finderne Plant, Somerville, N. J.

Circle 471 on Inquiry Card



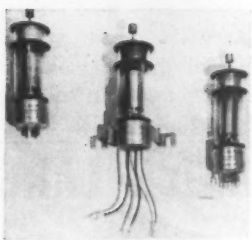
Tiny Impulse Generator

Designed to convert mechanical motion to an electrical signal without mechanical contact, midget impulse generator provides an accurate means of measuring, counting or detecting movement, vibration or speed of a shaft or other part. The device, without any external excitation, produces an output frequency that is proportional to any movement of ferromagnetic materials near its sensitive end. Built-in Alnico V magnet furnishes self-excitation.

Directly, or with suitable amplifiers, relays, voltmeters, frequency counters, etc., the midget impulse generator may be used to indicate electrically the speed of shafts, vibration of parts, angular or linear position of pins, wheels, levers, cams, slots, holes, pistons, etc.; and to serve as a tachometer.

Units are 3/8-inch in diameter and 1 inch long. Construction is such that they will stand operating temperatures to 500F. **MinAtron Corp.**, Belle Mead, N. J.

Circle 472 on Inquiry Card



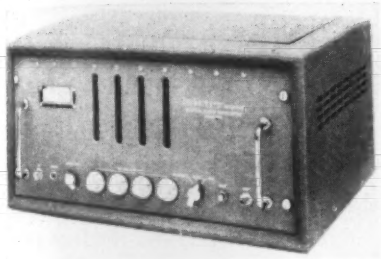
Control Thyratron

Designed to provide reliability and to offer equipment designers three different base connections, control thyratron is a 6.4-amp negative control characteristic unit. Models GL-6807, GL-6808, and GL-6809 incorporate element and envelope construction designed to provide maximum cooling to eliminate major causes of inoperation resulting in loss of factory time and possible damage to equipment. The GL-6807 has a pin-type base and can be used interchangeably with the GL-5545. The GL-6808 has flexible flying leads and the GL-6809 is made with spade lug terminals extending from the base.

Because they carry high commutation factor ratings, thyratrons are well suited to motor control and other inductive load circuits without cushioning. Units operate over a wide ambient temperature range (−55 to 70C) and feature

a quick-heating cathode (1 minute). New anode and grid structures feature relatively large external surfaces which permit cooling by convection as well as radiation. Lower operating temperature safeguards against grid emission. In turn, lower grid emission permits elimination of an internal baffle. **General Electric Co., Tube Dept.**, Schenectady 5, N. Y.

Circle 473 on Inquiry Card



Digital Flow Indicator

Tailored to fill the need for a production testing instrument compact enough to move from test bench to test bench for calibrating flow meters and making actual flow measurements, complete digital flow indicator system is packaged in one compact unit. The system combines the features of Berkeley's 7150 EPUT meter and 5424 preset counter to create a highly accurate digital instrument for measuring fuel flows.

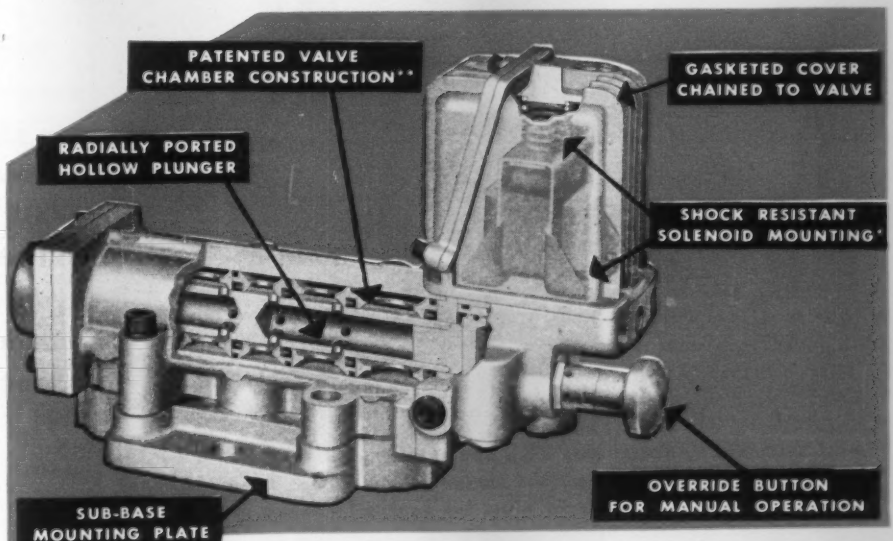
Front panel features a four-digit presentation reading directly in either pounds per hour or gallons. Direct flow rate indication runs from 0 to 9999 lb per hour. The time base may be selected from 1 millisecond to 10 seconds, in increments of 1 millisecond. Digital flow indicator includes complete test and flow totalizing qualities, and is engineered to operate with any impeller type transducer. It can be modified for use with two or more different transducers.

Accuracy is ± 1 count, and time base stability is one part in 10^5 short term. Binary decimal coded output from the decimal counting units will operate any standard digital recorder, in-line converter and readout unit, or data reduction equipment. **Berkeley Div., Beckman Instruments,** Dept. 3639, 2200 Wright Ave., Richmond 3, Calif.

Circle 474 on Inquiry Card

Quick-As-Wink®

"B"-TYPE HIGH SPEED, HIGH CAPACITY SOLENOID VALVES


PATENTED VALVE CHAMBER CONSTRUCTION**
GASKETED COVER CHAINED TO VALVE
RADIALLY PORTED HOLLOW PLUNGER
SHOCK RESISTANT SOLENOID MOUNTING*
SUB-BASE MOUNTING PLATE
OVERRIDE BUTTON FOR MANUAL OPERATION

...offer many NEW advantages to make automation less costly and more dependable

Conservatively rated at 600 cycles per minute for continuous operation, these new, high speed valves feature:

1) **SHOCK RESISTANT SOLENOID MOUNTING*** available only in Quick-As-Wink design, reduces destructive hammering and vibration, assuring *greatly increased solenoid life.*
2) **VALVE CHAMBERS** formed by aluminum spacers held in accurate metal to metal end abutment** and sealed with "O" rings and "U" packers.
3) **HOLLOW, RADIALLY PORTED STAINLESS STEEL PLUNGER** directs the flow through the valve. No lapped joints.
4) **GASKETED DIE-CAST COVER** finned for cooling, held with captive screws and chained to valve.
5) **OVERRIDE BUTTON** permits manual operation in case of power failure.
6) **SUB-BASE MOUNTING** permits valves to be inspected — and serviced if necessary — without disconnecting *any* of the piping.

Available also in Double Solenoid, Lever Operated and Pilot Operated Designs.

Get full details about this outstanding new valve. Write for Bulletin No. 561—Today!

*Patent Applied For **U. S. Patent No. 2,645,450

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

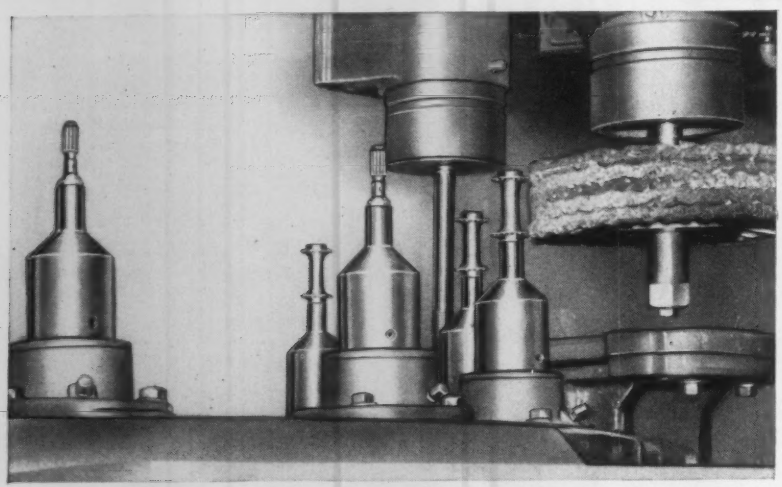
Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2072 East Pershing St., Salem, Ohio

Circle 610 on Inquiry Card

Self-release, greater grip, automatic alignment of ERICKSON MANDRELS speed small to large part loading



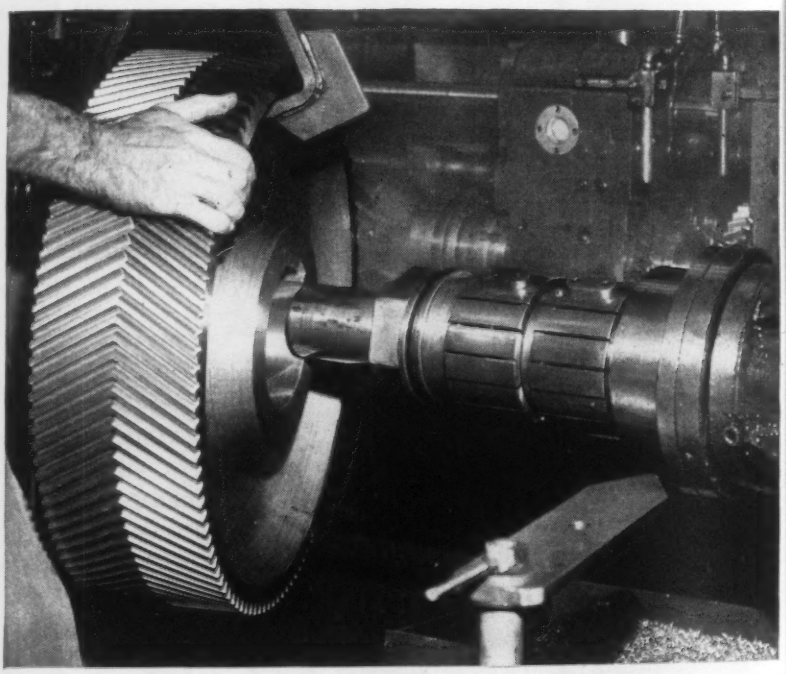
SMALL ERICKSON MANDRELS play a big part in holding down production costs for leading bicycle parts manufacturer. Here you can see how Erickson drawbar-operated, precision expanding mandrels speed wheel hub loading for buffing operation. Ease of operation and instantuneous release have greatly speeded this quantity production holding problem.

Regardless of size, Erickson precision expanding mandrels operate on Erickson's famous double-angle principle that not only assures guaranteed accuracy of .0005" T I R, but also makes mandrels self-releasing. They are available for air, hydraulic or manual operation. Special mandrel sleeves are designed to match various internal forms. AA-72

ERICKSON MANDREL ADVANTAGES

- Instantaneous self-release greatly speeds loading and unloading
- Greater holding power because grip extends over entire sleeve length . . . stops wobble and chatter
- Guaranteed accuracy of .0005" T I R
- Each sleeve covers a range of 1/32"
- Sleeves are interchangeable on mandrels of same series

Are you bothered by a tough internal holding problem? Then let us prove that Erickson mandrels speed production for lower unit costs. Give us a call today or write for catalog K.



ERICKSON MANDRELS speed large part handling, too. See how easily this heavy shovel gear, 24 inches in diameter, is being loaded for gear cutting at the Alten Foundry and Machine Works, Inc., Lancaster, Ohio. Larger shovel gears up to 61 inches in diameter are handled just as easily. At Alten Foundry, using an Erickson mandrel, loading and automatic alignment require only 10 percent of the time required by plants using solid arbors and arbor presses. Even this large mandrel is self-releasing. Operator fatique is practically eliminated.

ERICKSON TOOL COMPANY

2307-10 Hamilton Avenue • Cleveland 14, Ohio

COLLET CHUCKS • FLOATING HOLDERS • TAP CHUCKS • TAP HOLDERS • AIR-OPERATED CHUCKS
EXPANDING MANDRELS • SPECIAL HOLDING FIXTURES

Circle 611 on Inquiry Card

catalogs and literature

Latest automation information. For copies use card page 17.

Barrel Finishing Systems

Almco Div., Queen Stove Works Inc., Albert Lea, Minn.—12-*page bulletin* — Automated submerged type barrel finishing systems which provide high production descaling, deburring, grinding and burnishing, are described and illustrated in bulletin. Skip-Station system can simultaneously process parts requiring different finishes; In-Line system is suitable for finishing parts of different kinds, requiring the same finish and processes. Both feature automatic programing and materials handling.

Circle 475 on Inquiry Card

Industrial Hose & Fittings

Aeroquip Corp., Jackson, Mich.—12-*page bulletin*—Socketless fittings, low, medium, and high pressure hoses; adapters and self-sealing couplings are covered in Bulletin No. 174. Ordering information, installation planning, assembly instructions, photographs, and complete specifications for numerous models of each component are included.

Circle 476 on Inquiry Card

Electromechanical Breadboards

Servo Corp. of America, 20-20 *Jericho Turnpike, New Hyde Park, L. I., N. Y.*—16-*page booklet*—Components and three basic kits used for breadboard models of control or guidance systems, analog computer subassemblies, servomechanisms, motor drives, gear trains, timers and regulators are discussed in booklet. Items available include mounting boards, hangers, shafts, gears, couplings, adapters, clamps, clutches, differentials, cams, microswitches, pulse disks, load disks, limit stops, terminal assemblies, dial assemblies and handcranks.

Circle 477 on Inquiry Card

Precision Thermistors

Fenwal Electronics Inc., Mellon St., Framingham, Mass.—12-*page bulletin*—Used in electronic circuitry and electromechanical instrumentation, line of precision thermistors is described in Catalog EMC-1. Specifications and dimensional drawings of various forms of thermistors, including beads, rods, disks, washers and built-up assemblies, are included. Discussion and schematic circuit illustrations of actual thermistor applications are also given.

Circle 478 on Inquiry Card

Spraying Guide

Finish Engineering Co. Inc., 1115 *Cherry St., Erie, Pa.*—36-*page catalog*—Masks, vacuum plating racks, spray painting machines, mask washers, automatic paint wipers, paint and wipe machine, painting fixtures, decorating screens, and production roller coaters are illustrated and described in catalog. Illustrations in color show the parts which are processed by different types of painting equipment.

Circle 479 on Inquiry Card

Relief Valves

Fluid Controls Inc., 1284 *N. Center St., Mentor, O.*—16-*page booklet*—Variety of basic relief valves including pilot, differential piston, guided piston, spring loaded and dual relief types is illustrated and described in booklet 551. Each type of valve is described with engineering drawings, performance charts, specifications and operating data. Separate section in booklet is devoted to factors to be considered in selecting the proper relief valve for a specific job.

Circle 480 on Inquiry Card

Variable Speed Drives

Allis-Chalmers Mfg. Co., 1205 *S. 70th St., Milwaukee, Wis.*—44-*page catalog*—Selection tables for four types of variable speed drives are included in catalog 20P50, which lists four essential factors in drive selection as: Hp requirement, desired center distance, rpm of driver and speed range of driven machine. Information on design features, drive principles, speed range table showing the variation in rpm when using two Vari-Pitch sheaves in combination, and accessory equipment information are included.

Circle 481 on Inquiry Card

Thermocouple Assemblies

Conax Corp., 7811 *Sheridan Dr., Buffalo* 21, *N. Y.*—28-*page catalog*—High accuracy of measurement and control is provided by unshielded thermocouples discussed in Catalog 1556. Conax thermocouple glands are used to seal the bare thermocouples in any chamber operating above or below atmospheric pressures. Other thermocouple assemblies covered include Check Wells, which combine sensitive thermocouple with dial type thermometer; Speedwells for checking temperature gradients; packing glands, etc.

Circle 482 on Inquiry Card

Automatic Can Making

E. W. Bliss Co., 50 *Church St., New York* 7, *N. Y.*—16-*page booklet*—Line of bodymakers, power formers and duplex seaming presses for medium and high speed can making lines is described in Catalog 36B, Section 3. High speed bodymaker which produces 450 cans per minute; high and medium speed bodymakers for round, square and rectangular cans; and high speed machine for dry packages are illustrated. Design and construction features and dimensions of all machines in the line are given.

Circle 483 on Inquiry Card

Trolley Conveyors

Chain-O-Flex Corp., Franklin Park, Ill. — 8-*page bulletin* — Construction and design features of line of trolley conveyors are discussed and illustrated in bulletin. System features automatic lubrication and automatic take-up; individual trolley is able to carry up to 75 lb without load bars or special attachments. Sketches illustrate stock vertical curves and horizontal turns which are available.

Circle 484 on Inquiry Card

Mass Spectrometers

Consolidated Electrodynamics Corp., 300 *N. Sierra Madre Villa, Pasadena, Calif.*—16-*page booklet* — Electronic instruments which are designed to continuously measure the amount of the various constituents in a process

stream are described in Bulletin 1824B. General design, performance characteristics and ordering information on the mass spectrometers are given. Photographs and brief description of typical applications are included.

Circle 485 on Inquiry Card

Metal-Ceramic Receiving Tubes

General Electric Co., Tube Dept., 1 River Rd., Schenectady 5, N. Y. 20-page booklet—Suitable for automatic assembly into electronic equipment, micro-miniature metal-ceramic receiving tubes are the subject of booklet ETD-1212-A. Tubes can be used in any electronic equipment requiring motion, high temperature, restricted space, automatic assembly and improved UHF performance. Tube features, specifications and application data are included in the booklet.

Circle 486 on Inquiry Card

Unloading Machines

Sahlin Engineering Co. Inc., P.O. Box 289, Birmingham, Mich.—16-*page booklet*—Iron Hand is the name given to self-contained, fully automatic unloading machine described in booklet. Information on the overhead Iron Hand, the portable model for floor operations, turnover and transfer machines and other unloaders is included. Various types of gripping jaws that adapt the unloader to a wide variety of conditions are described.

Circle 487 on Inquiry Card

Vibratory Feeder Equipment

Vibratory Feeder Co., Erie, Pa.—8-*page bulletin*—Base power units, blank cast bowls and fabricated supply hoppers are the types of feeder equipment covered in Catalog 5631. Photographs, specifications and application information of various feeder devices are included.

Circle 488 on Inquiry Card

Cable Conveyor System

Tipp Mfg. Co., Tipp City, O.—36-*page catalog*—Information needed to order and install a cable conveyor system, including a plan for layout of the system, is given in tabbed catalog. Automatic safety controller which provides warning and prevents damage from abnormal load conditions on electrically driven conveyor systems is also described and illustrated. Eight-step installation procedure; engineering specifications; formulas for calculating cable tension, corner loads and shaft stresses; and work clearance charts are included.

Circle 489 on Inquiry Card

Underdrive Presses

Danly Machine Specialties Inc., 2100 S. Laramie Ave., Chicago 50, Ill.—32-*page catalog*—Used for volume production of large stampings, automobile and major appliance body sections, etc., line of single, double and triple-action underdrive presses is the subject of illustrated catalog. Construction features of the presses are shown; specifications and dimensions are listed; press accessories such as bolster plates, dual air valve, etc. are described.

Circle 490 on Inquiry Card

Data Handling Systems

Berkeley Div., Beckman Instruments Inc., Dept. 3650, 2200 Wright Ave., Richmond 3, Calif.—8-*page bulletin*—Engineered systems for data reduction, data handling, data logging, industrial measuring and recording, and industrial process controls are described in Catalog C-703. Three analog computers and four components for control systems are outlined. Amplifiers, electronic multipliers and function generators are covered.

Circle 491 on Inquiry Card

Machine Tool Power Unit

Ex-Cell-O Corp., 1200 Oakman Blvd., Detroit 32, Mich. — 20-*page booklet*—Quill type hydraulic power units which are used in step drilling and other machining operations are the subject of booklet 45352. With power units, automatic drilling of deep holes is possible. Illustrations of units being used for feeding and rotating cutting tools are included. Engineering data, specifications and examples of typical applications are also given.

Circle 492 on Inquiry Card

Index Tables

Ferguson Machine & Tool Co., P. O. Box 5841, St. Louis 21, Mo.—26-*page catalog*—Precision indexing at high speeds for large volume production is provided by line of index tables and rotary transfer machines described in Catalog 301. Line, including dial sizes ranging from 12 to 120 inches with from four to 36 stations, features precision without auxiliary locking methods, and production speeds up to 30,000 pieces an hour. Power and drive assemblies, electrical control panels, dial clamps and tool mounting plates are also illustrated and described.

Circle 493 on Inquiry Card

Steel Strapping

Acme Steel Products Div., Acme Steel Co., 2840 Archer Ave., Chicago 8, Ill.—44-*page catalog*—Used for reinforcing, palletizing, bundling, baling, tying and throughout the entire materials handling industry, flat steel strapping is discussed in comprehensive catalog. Smaller, lighter sizes of steel strapping called Steelstrap; and the larger, heavier sizes, called Unit-Load Band, are illustrated with accessory tools and applications covered. Numerous application photographs illustrate variety of uses for steel strapping in automatic and semiautomatic installations.

Circle 494 on Inquiry Card

Hydraulic Power Unit

Crescent Tool & Machine Co. Inc., 1780 Southfield Rd., Lincoln Park 25, Mich.—12-*page bulletin*—Designed to provide economy for removing metal with rotating tools, Style Q-9 hydraulic power unit is discussed in bulletin 54. Electrical controls, feed strokes and control valves of the unit are illustrated and described. Other machine tool assemblies which are covered are: Automatic assembly machine, seven-station automatic transfer machine, four-station indexing machine, etc.

Circle 495 on Inquiry Card

Variable Pulleys

Lewellen Mfg. Co., Columbus, Ind. —18-*page booklet*—Designed to provide speed adjustability to motors and machines, variable pulley drive is described in Catalog 60A. Drive consists of a variable pulley, variable belt and adjustable base. Combination pulleys for different applications, and charts giving ratings of several variable pulley models are included.

Circle 496 on Inquiry Card

Industrial Trucks

Automatic Transportation Co., 149 W. 87th St., Chicago 20, Ill.—16-*page booklet*—Line of electrically driven industrial trucks which ranges in size from operator led models to fork and ram trucks capable of lifting loads up to 100,000 lb is described in new booklet. Series of gas-powered trucks with electric transmission which eliminates need for clutches, gears, overdrive or hydraulic torque converters is covered. Specifications of various models, their aisle width and turning radius are given.

Circle 497 on Inquiry Card

Recording and Controlling Units

Bristol Co., Waterbury 20, Conn.—64-*page catalog*—Electronic potentiometer and bridge instruments for recording and controlling are covered in catalog P1245A. Instruments discussed include recorders, automatic controllers, single and multiple variable recorders, sensing elements and special attachments such as resistance bulbs, magnetos, photocells, conductivity cells and frequency converters. Equipment in which instruments have been incorporated includes

strain gages, viscosity meters, thickness gages and gas analyzers. Principles of operation, specifications and photographs are included.

Circle 498 on Inquiry Card

Proximity Switch

Doelcam, Div., Minneapolis-Honeywell Regulator Co., 1400 *Soldiers Field Rd., Boston* 35, *Mass.—2-page pamphlet* — Used for applications where it is desirable to detect the presence of a ferrous object without physical contact, Model T-271 proximity switch is described in Bulletin PS. Diagram illustrates typical application, and performance specifications and installation drawings are included.

Circle 499 on Inquiry Card

Automation Engineering

Designers for Industry Inc., 4241 *Fulton Parkway, Cleveland* 9, *O.—6-page pamphlet* — The five phases which are covered by DfI in an integrated approach to the automatic factory are described in pamphlet. Analysis of market trends, redesign of products for automation, design of automatic machines, flexible materials handling equipment, and design of central control mechanisms are discussed.

Circle 500 on Inquiry Card

Tool Control Systems

Seibert & Sons Inc., Chenoa, Ill.—4-page pamphlet—Unit which includes tool holding board, bench, cyclometers, adjustable adapters, gages and fixtures is described in pamphlet. Advantages of tool control system are its facility for storing preset duplicate tools at the machine, reducing downtime and assuring efficient use of tools.

Circle 501 on Inquiry Card

Dial Feed Machine

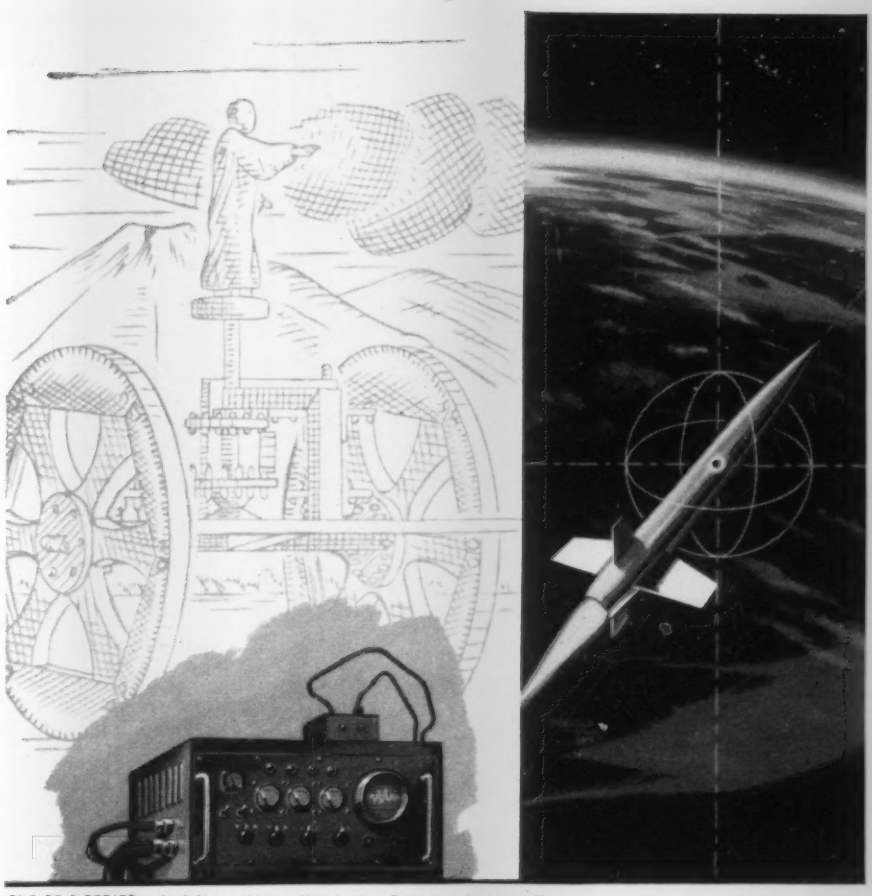
National Electric Welding Machines Co., 1846 *Trumbull St., Bay City, Mich.—4-page pamphlet*—Loading, resistance welding, hydraulic reaming, hopper feeding, pressing, hot upsetting and hollowing milling are performed on brake backing plates by dial feed machine described in Welding News, Vol. 10, No. 1. Illustration and brief description of the machine are included.

Circle 502 on Inquiry Card

Automatic Indexing Table

Pratt & Whitney Co. Inc., W. Hartford 1, *Conn.—2-page pamphlet*—Automatic angular positioning is available for inspection, calibrating and machining jobs through 42-inch rotary table with automatic indexing. Operating characteristics, specifications and photographs of the table are included in Circular No. 594.

Circle 503 on Inquiry Card



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Circle 617 on Inquiry Card

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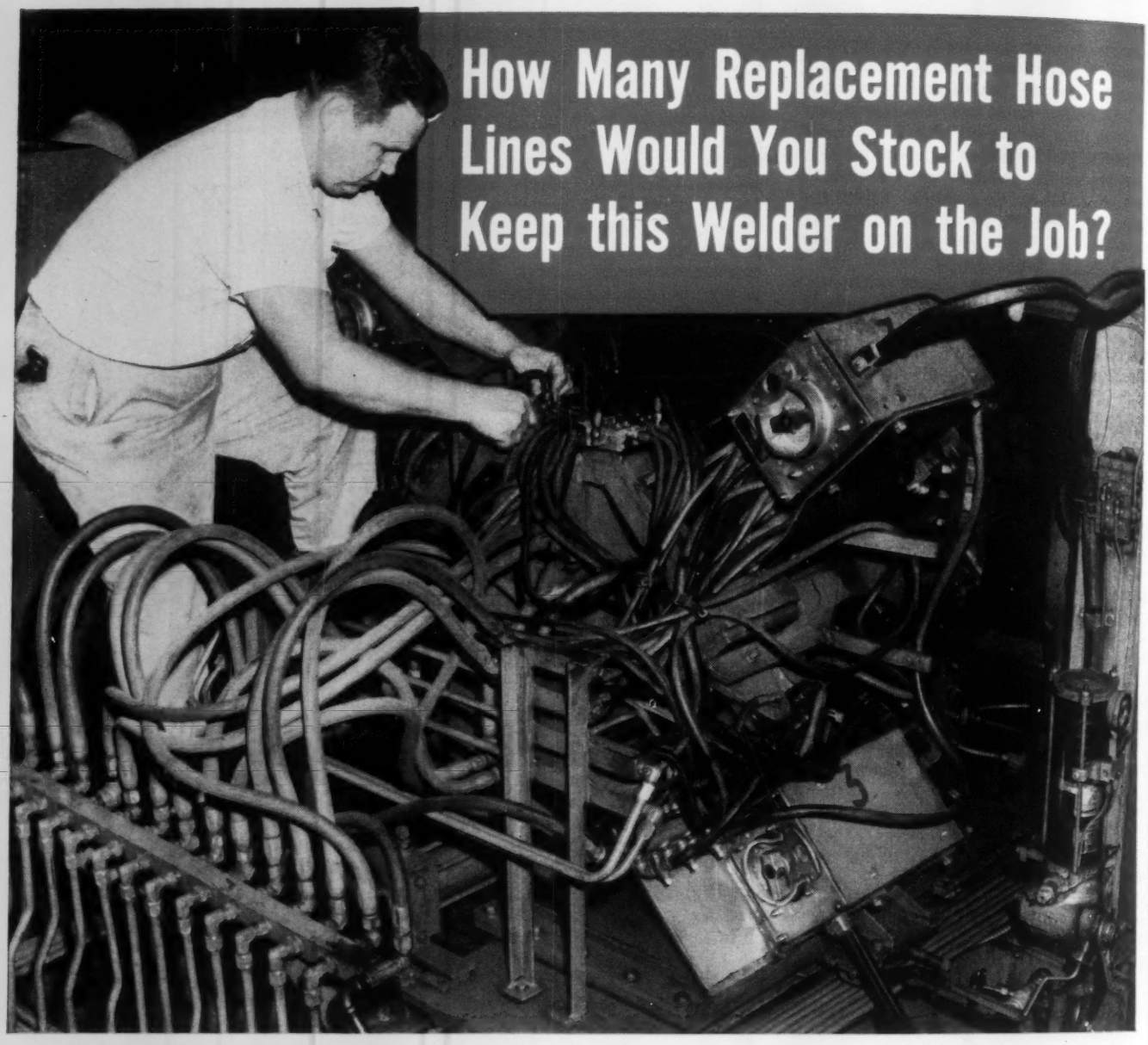

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Circle 618 on Inquiry Card

AUTOMATION abstracts

COMPUTERS IN MACHINE TOOL CONTROL

By J. JAMES STONE, Jr.
Assistant Chief of Electrical Engineering Div.
Battelle Memorial Institute

IN THE PERIOD since World War II, automatic computing machines and their accessory devices have contributed materially to advancement in many different kinds of endeavor. A decade ago, these machines were designed for and applied to the solution of problems in the major scientific research and engineering development programs. Later, government agencies and large industrial concerns explored the possibilities of these machines for solving problems in accounting, inventory control, management, production scheduling, record keeping, data processing, and many others. In all of these areas computing machines are being used successfully and development work continues to extend their usefulness.

More recently, these machines and special devices involving similar principles of operation have appeared for the control of machine tools. Computer-controlled machines are making production more automatic, and, consequently, are influencing the advance of automation.

To some, automation implies the control of individual machine tools by computing machines. To others, automation concerns the entire factory, and computing machines assume a major role both in the office and on the production line. The latter concept involves the completely automatic flow of material from the input of raw materials to the output of the finished product. Production would be scheduled automatically in accordance with the demand. Except for oil refining, chemical process plants, etc., in general the physical realization of this automatic factory is not in the immediate future. Progress is being made, however, in the development of techniques and methods for controlling individual machine tools and regulating the flow of materials in hard goods production.

Before machine tool manufacturers and designers may intelligently evaluate the impact of this technology upon their own field, it is essential that the basic operating principles of these devices be studied and understood. To many, a computer consists of large black boxes with a myriad of panel lights and controls. These are envisioned as being designed partly by witchcraft and partly by chance and capable of performing all sorts of mathematical magic, maybe even original thought. With such devices, it would be but a matter of time and machine training before these robots would replace skilled labor and assume a responsible role in both labor and management.

Luckily, this concept of computers is not true. These machines are based upon simple logic and perform fundamental operations at a great rate of speed. Of course, no original thought by these machines is possible. They perform fundamental operations in a predetermined fashion as prescribed by the machine operator.

Classification of Computers

Depending upon the form and nature of the information handled, computers may be divided into two major categories. The distinction between these two categories may be explained by a hypothetical blueprint that might be given a machinist to show him how a cylinder is to be machined. Two methods are employed to convey to the machinist the concept of the size of the cylinder. First, the drawing is made to scale so that the physical distance in the drawing bears a definite relationship to the finished dimensions of the piece. By means of a ruler or scale, the machinist may, if he chooses to ignore the numerical dimensioning, measure the dimensions in this sketch and determine the approximate physical size of the finished article. By this measurement, the machinist converts the distance along the sheet of paper into a numerical quantity.

Displaying the numerical quan-

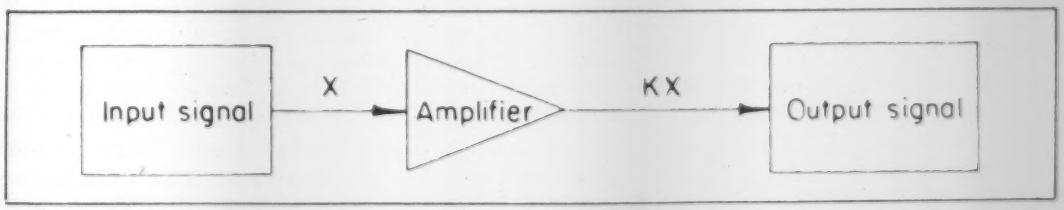

Fig. 1—Block diagram of an open loop control system. The input signal is amplified by the controlling amplifier to produce the output signal.

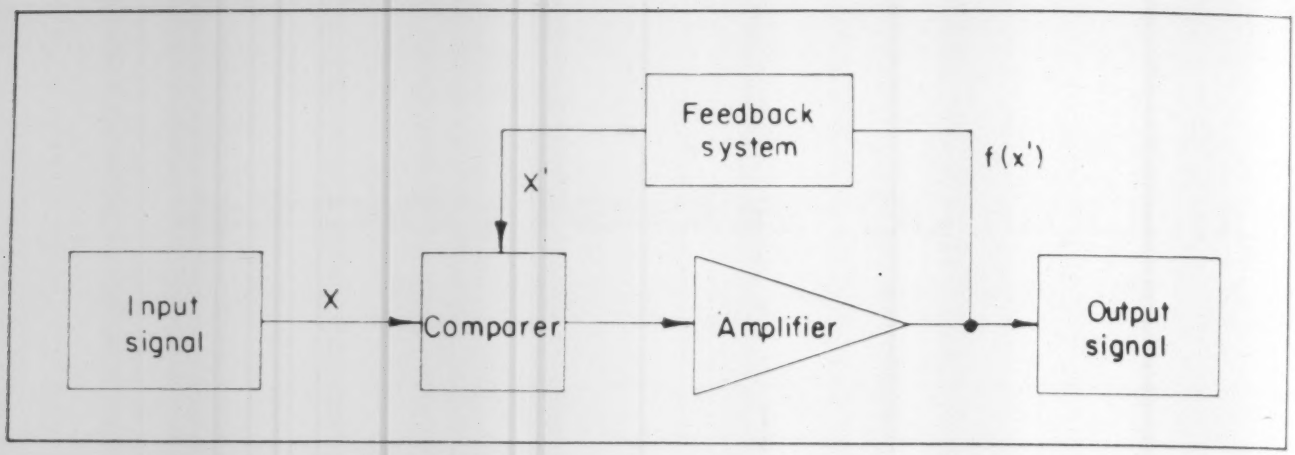

Fig. 2—Closed loop control system. Difference between input and output signals is basis for correction which tends to keep input and output signals reconciled.

tity on the drawing is the second method of conveying to the machinist the physical size of the article. It may be noted that in the process of measurement, the machinist converted the concept of distance on the drawing to numerical form and so changed the first method of conveying size into the second.

In preparing this drawing, the draftsman has complete freedom in varying the distance between the lines representing the outer dimensions of this cylinder. The distance between these lines may, therefore, be described as being continuously variable. The numerical quantity used to describe the dimension, however, is not continuously variable — representation of dimensional changes is by discrete steps.

Computers that handle information as continuous variables are referred to as analog computers. In general, the magnitude of a single quantity in a computer, such as the magnitude of a voltage or current, represents the magnitude of the information being handled. A computer that handles and operates upon information of a discrete variable type is called a digital computer. A single quantity, such as a voltage or a current, is not used in a digital computer to represent the entire magnitude of the information handled. In the majority of cases, voltages and currents are limited to being either present or absent, on or off, and can exist in the computer in only these two states. A combination of a large number of these quantities is employed to represent the numerical quantity being operated upon. A four-decimal digit number may require as many as 16 of these voltage variables for its representation within the computer.

Digital Versus Analog

The majority of modern control systems utilize continuous variables and employ analog type computational systems. Servocontrol systems exemplify this type of system.

As the links become available for the inclusion of a digital computer as a portion of a control system, a debate arises regarding the relative merits of analog and digital. Many factors influence the decision as to which machine, the digital or the analog, performs best in a given application. These factors include such considerations as accuracy, flexibility, complexity, and reliability, and these must be evaluated in terms of ultimate cost. Each consideration depends upon the specific application and those that may be important under one set of conditions may be neglected for others.

Accuracy, for instance, is normally considered as being considerably greater for digital computations than for analog computations. This comes from the fact that a large number of digits may be used to represent a numerical quantity to a high degree of precision. However, some error is introduced in each basic operation in a digital computer where roundoff of results occurs and for a large number of such operations, the roundoff errors may accumulate. Furthermore, the availability of 10 digits does not provide assurance that these digits will be used in an effective manner. It is possible, for example, to use 10 digits (as 0.0000000561) where only the latter three carry any significance.

In general, however, the overall accuracy of an analog computer system is limited and may be of the order of 0.1 per cent of the full scale value of the variable concerned. The accuracy of a digital system is limited by the digit capacity, but this capacity may be extended easily by adding additional circuit elements.

Flexibility and complexity may be determining factors. Certain operations may involve the storage of information and a recall of this information at a later point in the cycle. A digital system provides memory without leading to complex circuits arrangements. Ability to control the operating features of a digital computer by means of numerical input information may lead to a greater degree of flexibility. On the other hand many analog systems may be simply constructed and may cost far less than the barest minimum of digital computing equipment.

Reliability, or dependability, becomes a more serious problem as the complexity of a system increases. Digital computers involve many circuit components and a very low probability of failure is required of each to assure proper operation over extended periods. Many errors produced by circuit failure in a digital computer are difficult to detect and may be

serious in their consequence. Analog computers, on the other hand, more frequently result in complete failure of the machine's operation because of the failure of a single component. These errors are easily and quickly detected. Drift in the operating characteristics of an analog computer produces errors of rather small magnitude but these may affect the dependability of the results.

Basic Control Systems

In designing or analyzing control systems, two basic types are considered. The first of these, shown by the block diagram of *Fig.* 1, is open-ended. In this system, the input signal is amplified, or modified, by the controlling amplifier to produce the output signal. The input signal may be considered to be a demand signal such as a demand for a given position, or a demand for a given speed. The output signal may be considered as representing the change to be produced in the element being controlled, such as a change in its position or a change in its speed. In this case, the amplifier is considered as containing both the components for power amplification or control and the mechanism for producing the desired change.

For the open-ended system, the accuracy of the change produced compared to the demand depends upon the calibration of the amplifier and the extent to which the amplifier might drift. Likewise, the load conditions on the function being controlled may affect the amount of change produced for a given input signal.

To overcome this difficulty in the open-ended system and to improve the overall accuracy of the system, a closed-loop system was developed. The nature of this type of control is shown as a block diagram in *Fig.* 2. The input signal for this circuit connects with a comparer circuit along with a portion of the output signal. The difference between the two signals connected to the comparer is amplified and used as the output. For this reason, the amplifier gain should be sufficiently high to reduce the required input from the comparer to a value below the

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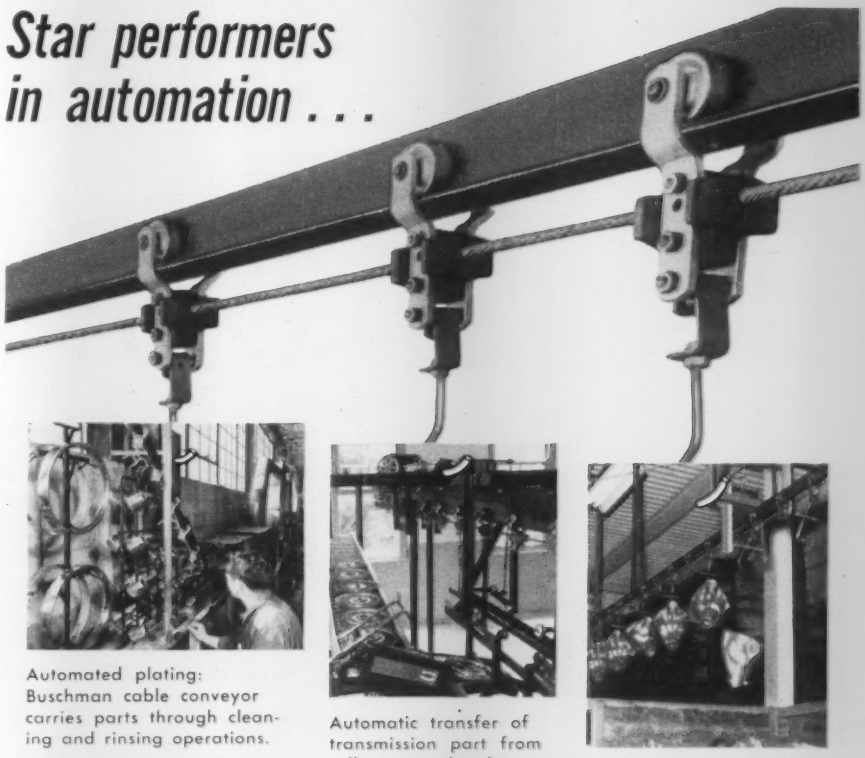

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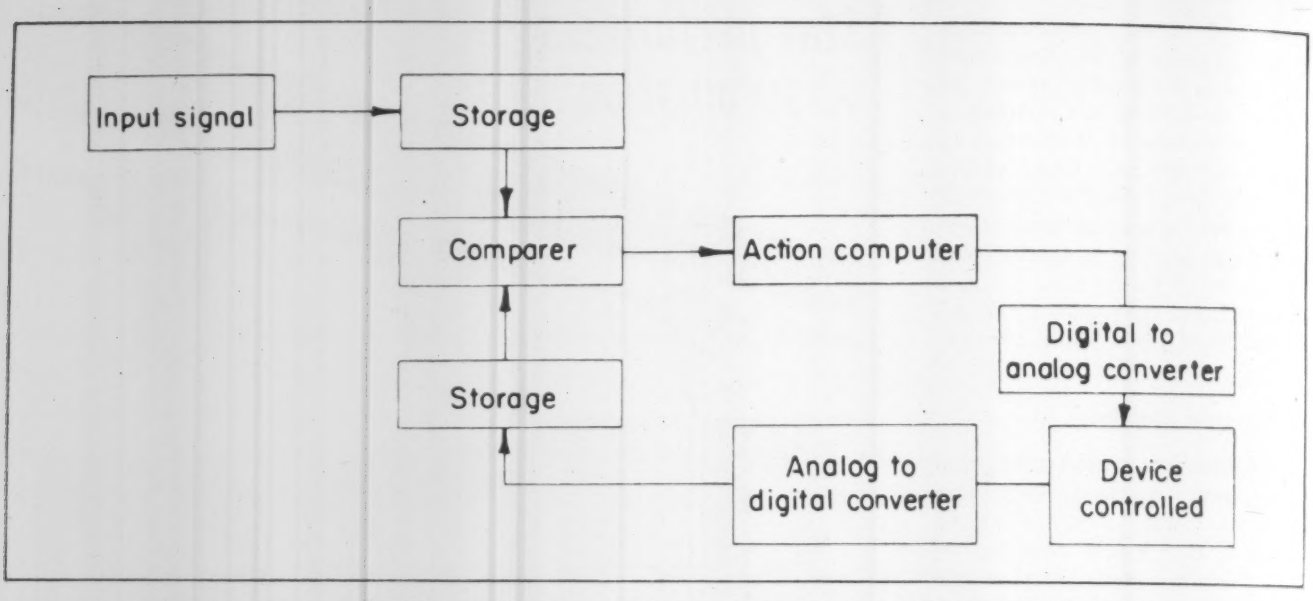


Fig. 3—Closed loop control system showing necessity for analog-to-digital and digital-to-analog conversion when input signal is in digital form and output signal in analog form.

error limits imposed on the system. By this means the two inputs to the comparer are forced to be equal and the accuracy of the output signal becomes dependent upon the feedback circuit rather than upon the amplifier.

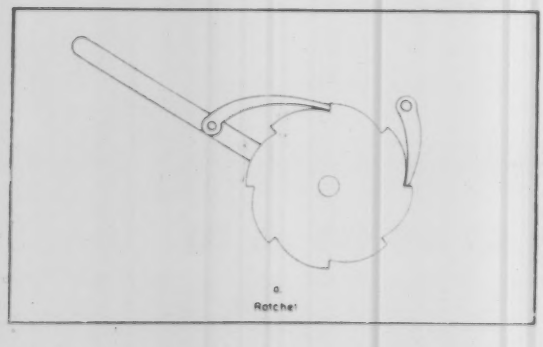
Accurate control of motor speed often involves this second method of control. An electrical voltage is produced that is equivalent to the desired speed of the system. A second voltage is produced by a tachometer that is equivalent to the actual speed of the system being controlled. The difference between these two signals is amplified and used to control the voltage source for the driving motor. By this means, if the output speed tends to increase, the difference signal is decreased and the voltage applied to the control motor is reduced, thus maintaining an approximately constant output speed.

Feedback may occur in many other ways. The machinist, for example, provides feedback in a manual control system of a machine tool. He measures the item being machined and adjusts the cutting tool to compensate for any error between the actual dimensions being produced and the dimension desired. Computing systems may provide feedback for control systems in more complex ways.

One method by which a digital computer might be employed in control is shown in *Fig.* 3. In this system, a numerical input signal is placed in the upper storage unit. The output signal, as converted to numerical form, is placed into a second storage unit. The comparer provides the computing circuit with the difference between these two numbers. The computer then, through a process programed in advance by the operator, determines the action to be produced in the controlled circuit. It is not necessary in this system that the output be proportional to the difference signal at the input to the computer. It is necessary that the output action should be capable of being determined in some logical manner. In a hypothetical case, a package filling machine may be filling a package to a predetermined weight with an assortment of ingredients. If each of these ingredients has a nominal weight differing from each of the others, it would be possible, after the weight of ingredients needed is measured, to compute the quantity of each ingredient so that the total weight added comes closest to that desired. The procedure for carrying out the necessary computations may be formulated into equations. By including a computer in the control system for the filling machine, the amount of feed for each ingredient may be immediately and automatically determined and the feeders actuated automatically.

Discrete Variable Machine Tools

The majority of machine tools operate through continuous drive mechanisms and controls. The tool feed on a lathe, for example.



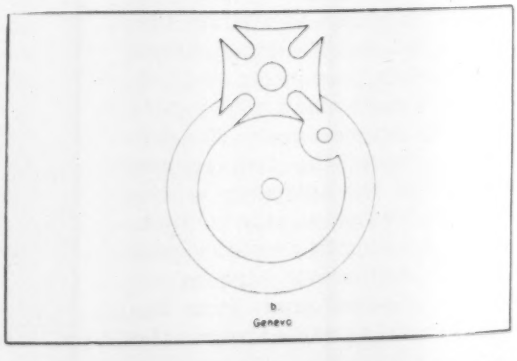


Fig. 4—The ratchet mechanism (a) operates from an oscillatory motion of the lever to produce discrete steps in the motion of output shaft. The Geneva mechanism (b) produces a rapid quarter-turn of the upper output shaft for each complete revolution of the input drive shaft.

moves continuously as the control crank is rotated. To employ digital control in these machines requires the inclusion of analog-to-digital and digital-to-analog converters as elements in the control system.

Through the development of machine tools that function in discrete steps, there is a possibility of simplifying the digital control of machine tools. The developments required include both intermittent motion of drive mechanisms as well as intermittent motion in the sensing devices that provide feedback for control.

Mechanisms are presently being used that provide the required drive from either an input shaft that moves continuously to a driven shaft which moves intermittently or from an input shaft that moves intermittently to an output shaft which moves in a like manner. Two examples of these mechanisms are shown in *Fig.* 4.

This paper serves as only the barest introduction to the broadening field of computing devices and machines. The principles involved in their operation may carry out many varied tasks and solve many difficult problems. Special purpose machines are rapidly appearing on the market that meet needs arising in industry. A punched paper tape controlled milling machine is one good example. But every application need not involve elaborate computing systems nor the control of large machines. The rather small, analog-type, machinability calculator indicates what can be accomplished with a small, low-cost device to assist machine tool operations.

Some of the devices provide assistance to the machine operator in carrying out his duties. Others convert ordinary machine shop tools into automatic, flexible machines capable of turning out small-lot jobs at prices that could become competitive with larger lot, assembly line jobs. Thus, the job shop achieves some of the advantages long enjoyed by the large production shops. This may come about without the job shop resorting to development of or investment in special machines for special jobs as has been the case in Detroit automation.

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the solution of discrete problems and have gained a reputation in the scientific and engineering fields. Business has employed them to carry out routine clerical operations, prepare payroll vouchers, and the like. These have been one-shot operations upon discrete units of data. There has been no feedback or control involved. Use of these machines in jobs that permit or require control of some portion of a system is unusual whether it be a mechanical or an information system. As for any further innovation, it is impossible to foresee all the applications and ramifications that may be encountered. Large development programs are underway in many areas, but much more research and development are required to approach the full utilization of this technology in the field of control.

From a paper entitled, "Introducing Computers for Machine Tool Control" presented at the annual meeting of the American Society of Tool Engineers in Chicago, March 1956.

POTENTIAL IN CANADA

By J. J. BROWN
Consulting Engineer
Montreal, Canada

EXAMPLES of high degrees of mechanization can be seen in many Canadian factories. Some of our petroleum and chemical plants have highly automatic continuous-flow processes. Others use a wide variety of electronic and other processes to control specific processes.

But, if we mean by automation a qualitatively different way of looking at all aspects of the production and distribution process, from product design through marketing, then it is no exaggeration to say that automation is unknown in Canada. This is too bad, because Canada, with her economic situation, her job-shop industry, her tax laws, her high rate of population growth, her strategic location close to the United States, and with the broad nature of her engineering education, is in many ways ideally placed to become a world leader in automation. In Canada, the gross national product per capital is in the range of 70 to 75 per cent of that in the U. S. This means there is more room for the development of automation here.

I have pointed out that the ideal seed ground for automation is not the large-mass production industry, but the job-shop. Here in Canada, virtually all our plants are job shops. Moreover, simply because its plants and businesses are relatively small, Canada provides an area in which new applications of automation to manufacturing, data processing, and so on, can be tried out on a small scale without disrupting large scale, closely integrated operations.

Thus many Canadian plants that are subsidiaries of U.S. and U.K. companies are in an ideal position to try experimental plant and office automation here. They can draw on the parent company for funds, yet not have to meet all the conditions required for capital expantion in their home countries. Moreover, test runs in Canada would

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be conducted a little out of the public eye, so that if they failed, (as experiments often do) the parent company would avoid unfavorable publicity.

Automation is innovation, and innovation is risky. Canada is an ideal country for the development of inherently risky ventures, because there is no tax on capital gains, and there is a climate of opinion favoring the taking of long odds for a large potential profit.

Canada's high rate of population growth, firmly backed by great raw material resources, is another reason why automation might develop very rapidly here. Between 1939 and 1953 Canada's population increased 30 per cent as compared with a 20 per cent increase in the U.S. Since we are going to be building new production facilities anyway, it is relatively easy for us to introduce automation.

Our strategic position close to the U.S. means that all the highly professional engineering of consent that goes on down there is brought to bear on us through U.S. newspapers and magazines. Reading about what the Americans are doing makes our executives stir uneasily, and wonder if they shouldn't be doing something too.

Not only do we have the strategic requirements, but we have the people. Perhaps because of the British influence on our educational system, the training of Canadian engineers is somewhat less narrow than in most U.S. schools. This makes graduates more hospitable to imaginative solutions to business and industrial problems, although an offsetting factor is the fact that the Canadian engineer has a less free hand in decision making than does his opposite number in the U.S.

Canadian scientists developed the first production tool controlled by electronic records; first ennunciated the concept of recording complex human skills; published the first discussion of automatism in a national magazine. They have gained international recognition as pioneers in automation over the past ten years. Thus there is no real reason why we should be behind in this field. Quite the contrary. With natural and political advantages on our side, and with well trained people, we could do work here that would be the wonder of the world.

From a paper entitled, "Automation, Men and Machines" presented at the Annual Meeting of the Engineering Institute of Canada, Montreal, May 1956.

NEED FOR AUTOMATION

". . . one of this country's problems is that its labor force is increasing at only half the rate of the general population.

"Our 30-year-old man is in the heart of the nation's labor force. He has too much work to do and it isn't likely that he'll get much help from other than engineers who can make his muscles and mind more useful. The low birthrate of the depression years and the death toll of World War II and the Korean action make it amply clear to economists that he'll just need to become more efficient, or he will have to be provided the tools to enable him to be more efficient.

"The labor force is increasing now at a rate only about half that of the general population. In April the labor force was 64 million and, of these, 2,600,000 were unemployed. It is this 64 million force which is increasing slowly while those in retirement increase more rapidly along with those not yet entering employment.

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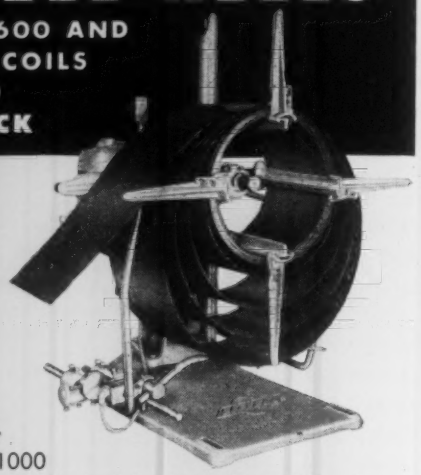

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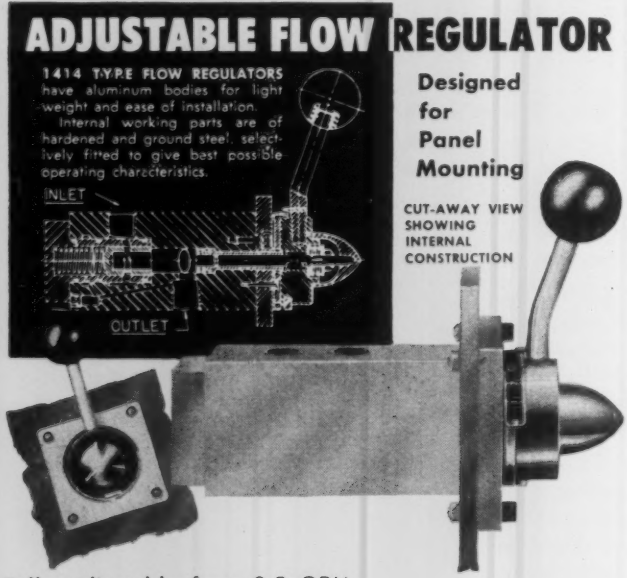
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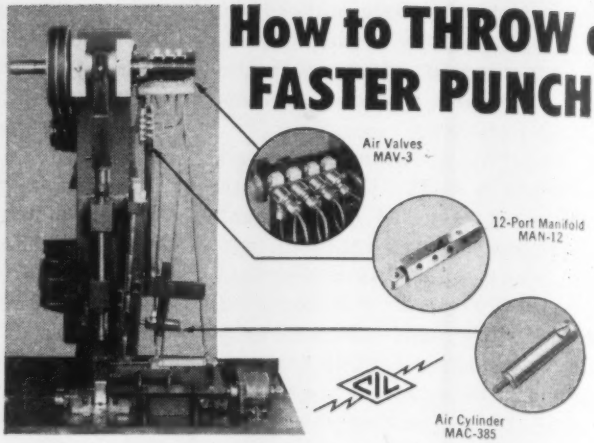

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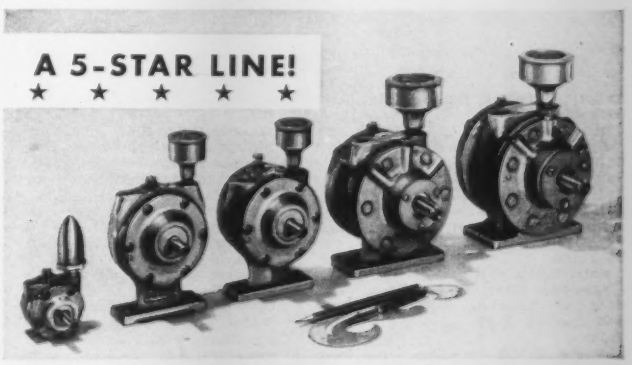

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2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5¼
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	7½
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Circle 630 on Inquiry Card

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